

*HOW TO DEVELOP AN INTERACTIVE ELECTRONIC
TECHNICAL MANUAL: AN INDUSTRY PERSPECTIVE*

THESIS

Ali N. Karabulut, B.S.
1Lt, TUAF

Hilmi Oz, B.S.
1Lt, TUAF

AFIT/GLM/LAL/98S-9

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

1 9990216213

AFIT/GLM/LAL/98S-9

*HOW TO DEVELOP AN INTERACTIVE ELECTRONIC
TECHNICAL MANUAL: AN INDUSTRY PERSPECTIVE*

THESIS

Ali N. Karabulut, B.S.
1Lt, TUAF

Hilmi Oz, B.S.
1Lt, TUAF

AFIT/GLM/LAL/98S-9

Approved for public release; distribution unlimited

The views expressed in this thesis are those of the authors
and do not reflect the official policy or position of the
Department of Defense, Turkish Air Force, or the U.S. Government.

***HOW TO DEVELOP AN INTERACTIVE ELECTRONIC TECHNICAL MANUAL:
AN INDUSTRY PERSPECTIVE***

THESIS

Presented to the Faculty of the Graduate School of Logistics
and Acquisition Management of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

Ali N. Karabulut, B.S.
1st Lieutenant, TUAF

Hilmi Oz, B.S.
1st Lieutenant, TUAF

December 1998

Approved for public release; distribution unlimited

Acknowledgments

We would like to express our sincere appreciation and gratitude to the members of our thesis team, Major William Scott and Professor Arthur Munguia, whose knowledge and experience were instrumental in completing this thesis. Without their encouragement and insightfulness this thesis would not have reached completion.

We are also indebted to O'Neil & Associates personnel who spent their valuable time explaining the processes and procedures they used in this IETM development project as well as their other procedures. We would like to express our gratefulness to Intercept project members, especially Ms. Janet Lawson, Ms. Renee Jones, Ms. Sally Habib, Ms. Debbie Evans, and Mr. Maan Khamis, for all their support and patience, who were always available to answer our questions

We also want to extend a special thanks to the Vice President and Marketing Director of O'Neil & Associates, Inc. Mr. Thomas R. Milligan for his more than willing support and help all along our study, who spent his every Friday with us during the most of our study and made everything possible for us.

1Lt Ali N. Karabulut

1Lt Hilmi Oz

Table of Contents

	Page
Acknowledgments.....	ii
List of Figures	vi
List of Tables	vii
Abstract.....	viii
I. Introduction	1
Overview	1
Problem Statement	8
Research Questions	9
Need for Research	9
Definition of Terms.....	9
Summary	9
II. Literature Review.....	11
Introduction	11
Standard Generalized Markup Language (SGML)	15
What is SGML?	15
What Makes SGML Special?	16
How Does SGML Work?	18
SGML Related Standards	22
Graphics.....	23
Vector vs. Raster Images	25
IETM Development Steps	25
Preplanning	27
Conversion Process.....	29
Database Management.....	37
Deployment.....	38

	Page
Five Classes of IETM.....	40
Class 0.....	41
Class 1.....	41
Class 2.....	41
Class 3.....	42
Class 4.....	42
Class 5.....	42
Today's IETM Environment	43
The Standard for Exchange of Product Model Data (STEP).....	44
 III. Methodology	 47
Introduction	47
Research Design.....	47
Unit of Analysis	49
Knowledge Acquisition.....	49
Data Collection.....	50
Summary	52
 IV. Case Study	 53
Introduction	53
Background	53
Is an IETM Really Needed?	54
Development of an IETM.....	55
Preplanning	58
Project Planning and Scheduling	65
Conversion Process.....	66
Data Enrichment	76
Database Management.....	77
Production Process.....	80
Quality Assurance.....	81
Final Product.....	82

	Page
V. Conclusions, Recommendations, and Suggestions for Future Research	84
Introduction	84
Lessons Learned	84
Conclusions	91
Driving Factors of Private Sector	91
Importance of Coordination and Using Standards.....	92
Role of the DoD in Establishing Standards	94
Role of Conversion in IETM Development.....	95
Future Considerations.....	95
Which Class of IETM?.....	96
Recommendations for Future Research	96
Summary	98
Appendix A: Glossary of Terms	100
Appendix B: Military and Industry Technical Manuals Delivery Specifications.....	111
Appendix C: Classes of IETMs	114
Appendix D: Summary of Research Questions Given to O'Neil & Associates.....	117
References.....	119
Vita.....	125
Vita.....	126

List of Figures

Figure	Page
1. Exponential Growth in Information Supporting Modern Aircraft	4
2. The Document Memo	19
3. Tree Structure of the Document Memo	20
4. Sample DTD: Document Type Definition for a Memo	20
5. Memo Document Instance	21
6. The “Ease of Conversion” Hierarchy	30
7. Various Components of Typical Documents	32
8. Chart for Relative Costs	34
9. Hard Copy Conversion	69
10. MS Word Conversion	70
11. Xyvision Conversion	72
12 Graphic Conversion	74
13. SGML Finalization	76
14. IETM Development Activities	90

List of Tables

Table	Page
1. What Questions Are Relevant for Each Research Strategy?	48

Abstract

Improvements in technology, especially in computer science, in last two decades have made it possible, and preferable to develop digital technical manuals. A digital manual, which is called an Interactive Electronic Technical Manual (IETM), is a package of information required for the diagnosis and maintenance of a weapon systems, optimally arranged and formatted for interactive screen presentation to the end-user. Being the largest organization in the U.S., the Department of Defense has pioneered in the development of IETM concept as well as in the establishment of its standards. There have been many researches done about different IETM applications and their effectiveness in DoD environment. However, little research has been done in the area of how an IETM is developed in a civilian environment. This thesis identifies what it takes to develop an IETM in a civilian environment and investigates differentiating factors of commercial industry. In addition to the identification of IETM development steps in a case study, IETM standards, IETM development specifications in industry as well as in military, problems areas in today's IETM development environment, and DoD classification of IETMs are also discussed.

HOW TO DEVELOP AN INTERACTIVE ELECTRONIC TECHNICAL MANUAL:

AN INDUSTRY PERSPECTIVE

I. Introduction

Overview

Advances in computer technology in the last two decades have given to the advent of Interactive Electronic Technical Manual (IETM). IETMs are designed to provide interactive display of required task procedures, and associated graphics to maintenance technicians or system/equipment operators. There are many applications in Department of Defense (DoD) as well as industry. DoD requires all new contracts require on-line access to, or delivery of, their programmatic and technical data in digital form (DoD 5000.2-R, 1998). So, what are the benefits of IETMs to technicians or system operator in the field, and to organization themselves? Mr. Tisdale, an action officer for the New System Training Division, Department of Training Plans and Evaluation, at the United States Army Aviation Logistics School, Fort Eustis, Virginia, expressed his thoughts about IETMs (Tisdale, 1998):

Have you ever chased an electrical problem on an aircraft? Usually on the third or fourth day since the fault was discovered, and at '0' dark in the middle of the night, and the aircraft "must" be ready to fly the most important mission of all times in just eight more hours, you think you have the problem pretty well figured out. After all, you have been through no less than five technical manuals and at least double that many wiring diagrams. No one can remember all the schematics and then find out that the manual that you are using is now referring you to yet another technical

manual to 'aid' in this fault isolation nightmare. Now, you are wondering if hiking back across the flight line only to carry out another ten thousands of manuals will actually identify the problem, or should you take the 100 pounds of manuals that you have amassed at the aircraft, stack them strategically around the problem aircraft, and go instead for lighter fluid? Thanks to the folks who envisioned DoD's first, class IV IETM, these types of problems will simply be "good ole day" stories to tell new maintainers.

So, it is not only the promises of new technological innovations in computer technology, but also some problems with paper manuals that give a push in the development of IETMs. Cost estimates for technical data delivered with DOD systems range from 10 percent to 30 percent of total acquisition costs (Pechersky, 1989). In particular, technical manuals consume large amounts of storage space (Masincup and others, 1995). For example, the B-1B bomber has a total of one million pages of documentation. A U.S. Navy ship carries 15 to 25 tons of manuals. It has been estimated that if this paper were removed, the ship would rise three inches in the water (Pechersky, 1989).

A report prepared for government identifies the problems with paper manuals in the following areas (Ventura, 1987):

- Amount, Weight, and Volume
- Inaccurate, Incomplete, Out-dated Information
- Complex, and Disorienting Information
- Less Portability
- Lack of Access to Information (Poor transportability and storage prevent needed documentation form being available at a maintenance location).
- Relying on Bad Information

- Relying on Usable Information for Maintenance (Maintenance information can become unusually complex and disorienting).

Another report prepared by same organization three years later classifies the problem areas with paper manuals into three groups (Conway, 1990):

- They are not portable
- It is difficult to keep them accurate, complete and up-to-date
- Needed information is difficult to find, understand and use

There may be other ways to solve the first two problems, whereas the third problem may be solved by organizing information much differently (Conway, 1990). A solution for third problem is the hypermedia (Conway, 1990), and IETMs are based on hypertext and hypermedia (Rivera, 1998). Hypertext is any text that contains links to other documents - words or phrases in the document that can be chosen by a reader and which cause another document to be retrieved and displayed. A link doesn't just have to be text, however -- pictures and icons can also be "clickable." Hypermedia is an extension of hypertext to include graphics, sound, video and other kinds of data.

One may still have questions whether the problems of paper manuals can't be really solved. Exponential growth of maintenance data required for supporting a modern aircraft is a good example for explaining the volume problem of paper manuals for today's modern technological systems (Conway, 1990) (See Figure 1).

Web page summarizes the problems discussed above (NAWCAD Web Page, 1998a):

The Navy was drowning in a sea of paper. In 1991 a life preserver came in the form of the AEGIS RCS Interactive Electronic Technical Manual (IETM), the first

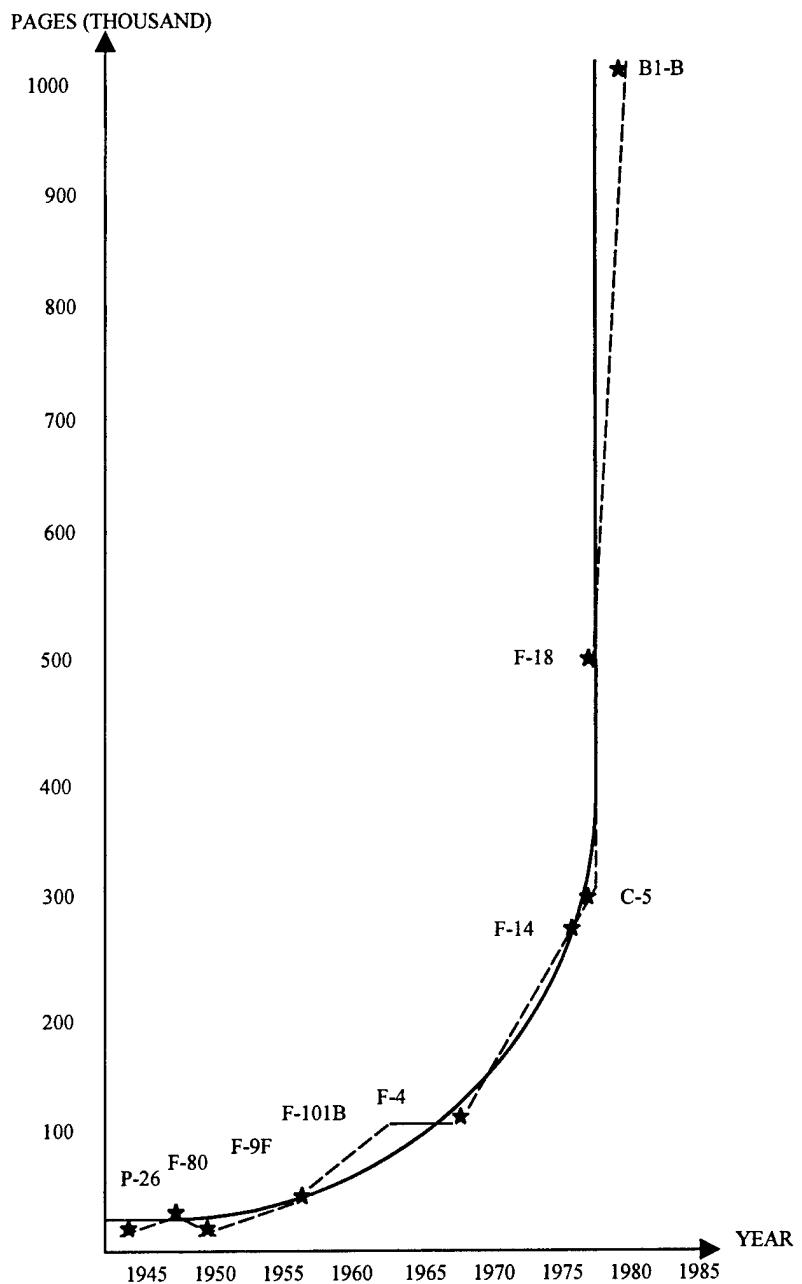


Figure 1. Exponential Growth in Information Supporting Modern Aircraft (Conway, 1990)

fielded Navy IETM. It reduced the burden of bulky, difficult-to-use technical manuals by providing an improved method for accessing technical information on a PC.

Do the problems with paper manuals solely explain the need for IETMs, one may ask what are the benefits of IETMs? Some benefits of IETMs can be summarized as follows (Advanced Integrated Maintenance Web Page, 1998):

- **Multiple Access to Documents**

When technical data is integrated into a computer database, it is accessible for multiple uses and applications (Munguia, 1997). It is possible that several users may reach the single copy of technical documentation in a network environment with IETM technology.

- **Rapid Search and Retrieval of Pertinent Information**

Advanced search algorithms with today's computer processing speed determine the location of pertinent data very quickly. Northwest Airlines, using a prototype system, experienced a minimum 50% reduction in airline mechanic's time spent looking for the appropriate documents. According to Villecca, as also discussed by Tomasetti, a technician spends 30% of maintenance time by searching for technical manuals (Villecca, 1997:17, 34).

- **No Deterioration Due to Handling**

Electronically rendered documentation is not subject to the normal wear and tear that is problematic to paper-based documentation.

- **Enhanced Troubleshooting**

Paper-based documentation plays only a passive roll in equipment troubleshooting. On-line access to maintenance information is expected to

yield a 35 percent improvement in trouble-shooting accuracy (Pechersky, 1989). Studies show that we retain 50 percent of what we both see and hear, but up to 80 percent of what we interact with (Martin, 1995). Using artificial intelligence (AI) methods embedded in the IETM, the documentation can take an active roll in maintenance. DoD's class 5 IETMs is an example of artificial intelligence embedded IETMs.

- Reduced Reproduction Costs

Electronic delivery of technical information provides substantial reproduction cost savings when compared to conventional paper-based methods. The U.S. Air Force has estimated an expected \$135 million annual savings in technical manual savings (Pechersky, 1989).

- Most Current Version Always Available

It is too typical that an update document will change the technical procedure in a technical document. Mr. Holloway, Air Force representative in Tri-service IETM working group, says that it would take 210 days to make a normal change to technical documentation in Air Force with paper manuals (Holloway, 1998). Implementation of an IETM would allow updates at a fraction of time. Using this method, documents would always contain the most recent changes and additions, reducing the chances of lost man-hours due to incorrect information.

- Reduced Weight

A typical document set is approximately 60% graphics and 40% text and tables. Based on these figures, a CDROM can store 3400 page units, or

roughly 20 pounds of information. Each CDROM, including storage case, weighs approximately 2 ounces; thus, the 37 tons of paper carried by the Aegis class ship could effectively be reduced to less than 1/4 ton of electronic media, a factor of 1/148.

- Reduced Volume

The 37 tons of paper aboard the Aegis class ship require approximately 1850 cubic feet of storage space. If replaced entirely with CDROM, the same documentation would take up less than 35 cubic feet. This savings more than offsets any requirements that a computer delivery system for the media might require. Also, dedicated hardware is not absolutely necessary, as office automation computers could host an IETM system with very few modifications.

- Reduced Combustibility

Unlike paper, magnetic and/or optical storage media are less likely to provide fuel for a fire. Also, in the event that this media is involved in a fire, the amount of fuel would be significantly less than that of paper.

Another benefit of IETMs is the decreased maintenance time by eliminating or reducing the time for removal and replacement of good parts (Munguia, 1998). IETMs are expected to give more accurate and quick diagnostics which allows the technician to go directly to the malfunctioning part. With IETMs, it is also possible to represent different levels of information from same database to technicians, or to operators with different skill level.

Advanced Integrated Maintenance, WWW summarizes the benefits of IETM with numbers (Advanced Integrated Maintenance Web Page, 1998):

- 50% Reduction in Time Spent Looking for Needed Maintenance Information
- 35% Improvement in Troubleshooting Accuracy
- 30% Reduction in Reproduction Costs
- Reduction in Weight of 148-to-1
- Reduction in Volume of 53-to-1

U.S. DoD was one of the first organizations that recognized the benefits of IETMs in terms of decreased cost in getting technical data, and increased effectiveness in the areas of maintenance, training, and operations. There have been many IETM development projects, in accordance with DoD 5000.2-R, throughout three military organizations, namely, Air Force, Navy, and Army. Some of these projects have been IETMs development from legacy data of exiting systems in inventories, whereas some other are based on new systems. U.S. DoD was also pioneering in the development, and recognition of standards that affected business in U.S. industry as well as other countries in the development of IETMs. However, little research has been done in industry about IETMs, especially in the area of development.

Problem Statement

This thesis will determine how an Interactive Electronic Technical Manual is developed in a commercial environment. It will identify necessary tasks to be accomplished in the development of an IETM. A case study of an IETM development project between an IETM developer company and its customer provides the basis for the accomplishment of the below identified research questions.

Research Questions

The specific research questions are:

1. What are the IETM development steps in an IETM development project?
2. What are the important considerations during each step of the IETM development?
3. What are the considerations that lead to IETM development rather than paper manuals in industry?
4. How is Quality Control/ Quality Assurance program is accomplished?"

Need for Research

Being the largest organizations in U.S., the military has pioneered development of IETM concept and its standards. There are lots of research on the benefits of IETMs, effectiveness of specific applications, and IETM related standards. However, there is a little research about what civilian industry is doing about IETMs, especially in the area of how IETMs are developed. This research will determine what it takes to develop an IETM in a civilian project. It will also identify important IETM development steps in this setting.

Definitions of Terms

A glossary of words used in this thesis may be found in Appendix A.

Summary

Chapter I provides background to the problem, presents a statement of the problem to be researched, the major research questions, and significance of the research. Chapter II provides a literature review of SGML and graphics standards, IETM

development steps, Classes of IETMs, and today's IETM development environment. The methodology used to investigate the research questions outlined in Chapter III. Chapter IV will present the findings of this case study in Intercept project, an IETM development project between O'Neil & Associates and Cummins Engine. Finally, Chapter V presents a discussion of the results, along with recommendations for further research.

II. Literature Review

Introduction

As defined in the DoD specifications, an Interactive Electronic Technical Manual (IETM) is a package of information required for the diagnosis and maintenance of a weapon systems, optimally arranged and formatted for interactive screen presentation to the end-user (Nawcad WebPages, 1998b). Kribs and Mark define an IETM as an electronic document that is assembled for viewing from a database of technical information and can interact with a technician to expertly maintain equipment (Kribs, and Mark, 1995). Shared characteristics of IETMs are (Nawcad WebPages, 1998b; Munguia, 1997:27):

1. The information is designed and formatted for screen presentation to enhance comprehension.
2. The elements of technical data making up the technical manual are interrelated. A user's access to required information is possible by a variety of paths.
3. The computer-controlled technical manual display device functions interactively (as a result of user requests and information input) to provide procedural guidance, navigational directions, and supplemental information.

Masincup adds three more characteristics to above definition (Masincup and others, 1996:632):

4. The technical manual is in a digitized form on a suitable medium, viewed by means of an automated authoring system.

5. It is designed for electronic display to an end user.
6. Varying degrees of interactivity, automated information links, graphics sophistication, and functionality are available.

IETM concept is a part of Continuous Acquisition Life-cycle Support (CALS) concept. CALS is a DoD and industry strategy to enable the integration of digital technical information, including technical manuals (TOs), for system/equipment acquisition, design, manufacture, and support (Munguia, 1997:9). The primary goal of CALS is to move from paper-intensive processes to integrated and automated processes.

One of the most visible and mature elements of the CALS has been the development and identification of electronic publishing standards (Bayne, 1989:73). The following standards are familiar in electronic publishing sector (Bayne, 1989:73; O'Neil & Associates, 1995a):

- Standardized Generalized Markup Language (SGML)
- Computer Graphics Exchange (CGM)
- Initial Graphics Exchange Specification (IGES)
- The Facsimile Compression and Transmission Standard (CCITT Group 4).

An IETM should contain digital chunks of information (text, graphics, precautionary statements) linked to each other in the groupings necessary to perform specific tasks (Delivery and Presentation Committee, 1991:1). Digital formats for technical illustrations in CALS concept are described in last three of above standards (Munguia, 1997:19), whereas SGML is metalanguage (which based on an international standard ISO 8879), whose purpose is to provide rules for managing, distributing, and publishing documents (Kribs, and Mark, 1995). As discussed in “Graphics” section,

graphics follow separate but parallel development steps with the text in an IETM development. These four standards will be further discussed under “SGML”, and “Graphics” section.

There are some specifications established by military and industry to standardize and give direction to the development of IETMs. In 1989, DoD established the Tri-Service Interactive Electronic Technical Manual (IETM) Technology Working Group to foster the exchange of ideas and the agreement on a common approach, regarding the acquisition of IETMs which use computer technology for the innovative display and presentation of technical manual information among all DoD agencies (IETM Technology Working Group Web Page, 1998). The group established three military specifications (Fuller, 1997):

- MIL-PRF-87268 defines how the IETM should look and behave to the reader (NAWCAD Information Technology Branch Web Page, 1998).
- MIL-PRF-8L7269 establishes the IETM database forms, structure, and key controlling mechanisms (NAWCAD Information Technology Branch Web Page, 1998).
- MIL-Q-87270 (cancelled).

One other specification used by the U.S. military is the SGML Implementation Guide (MIL-HDBK-28001). In addition to standardization efforts in the military, some industry organizations developed some specifications to guide IETM development efforts. ATA 100, ATA 2100, and ASE J2008 are familiar specifications in industry.

ATA 100 (Air Transport Association) specifies document type definition to be used in by the airlines and related manufacturers at development of technical manuals.

As opposed to the goals of MIL-HDBK-28001 DTDs which are the interchange and publication of data, the goals of the ATA-100 DTD are the interchange and management of airline data (Kusinski, 1991). Another specification developed by the Air Transport Association is ATA 2100. It establishes recommended standards for the presentation of technical information prepared as digital media (magnetic tape or CD-ROM) produced by aviation manufacturers and used by airlines and other segments of the industry in the maintenance of their respective products (Air Transport Association Web Page, 1998).

SAE J2008 is a family of standards developed by the membership of the Society of Automotive Engineers to provide easy access to emission-related automotive service information. At the heart of this SGML standard is a relational Data Model for Automotive Service Information rather than any particular document model. The SGML definition set forth within J2008 provides a hierarchical representation of the Data Model (SAE J2008 Web Page, 1998). (A comparison of specifications for digital delivery of technical manuals in military and industry is given at APPENDIX B).

It is important to understand that every IETM is different. The possible characteristics for an IETM application are limitless (Masincup and others, 1996: 633). DoD defines five classes of IETMs according to format, display and interactivity specifications to be used in military IETM development applications (this topic is discussed under “Five classes of IETM” section). According to the classification, an IETM to be class 3 and higher should be developed in Standardized Generalized Markup Language (SGML) (Jorgensen, 1994:3). SGML concept is discussed under “SGML” section. SGML is welcomed in IETM development industry since it offers some benefits other languages (markup, and word processing languages) can’t.

Again, it is important to remember SGML is not the only way to develop an IETM, but the one that is gaining more popularity and acceptance in the industry. For example, Portable Document Format (PDF) is also one of the preferred formats, especially with legacy data. However, SGML is emphasized in this chapter since the IETM development effort in the case study is accomplished by SGML.

The rest of the chapter is organized under following sections:

- Standardized Generalized Markup Language
- Graphics Standards
- IETM Development Steps
- Five Classes of IETM
- Today's IETM Development Environment

Standard Generalized Markup Language (SGML)

What is SGML?

Here are some common definitions for SGML:

“A universal language necessarily presupposes some basic or semantic primitives in which the notions of all other languages can be expressed” (Burnard, 1991).

“SGML is an international standard (ISO 8879), published in 1986, for the definition of device-independent, system-independent methods of representing texts in electronic form” (Sperberg, 1998).

“SGML Standard, ISO 8879:1986, defines an abstract syntax for defining many languages. Since SGML is really a method for defining many languages, each Document

Type Definition (DTD) potentially defines a different markup language; SGML itself is often called a meta-language" (Grosso, 1998).

What Makes SGML Special?

There are three characteristics of SGML which distinguish it from other markup languages: its emphasis on descriptive rather than procedural markup; its document type concept; and its independence of any one system for representing the script in which a text is written (Sperberg, 1998).

Descriptive markup, also known as "generic markup," describes the purpose of the text in a document rather than its physical appearance on the page. The basic concept of descriptive markup is that the content of document should remain separate from its style (Arbortext Web Page, 1995). By contrast, a procedural markup system defines what processing is to be carried out at particular points in a document. In SGML, the instructions needed to process a document for some particular purpose (for example, to format it) are sharply distinguished from the descriptive markup which occurs within the document. Usually, they are collected outside the document in separate procedures or programs (Sperberg, 1998).

With descriptive instead of procedural markup the same document can readily be processed by many different pieces of software, each of which can apply different processing instructions to those parts of it which are considered relevant (Sperberg, 1998). It allows multiple presentation of the same information. For example, you can publish on paper, on-line, on CD-ROM and on the World Wide Web (WWW), all from one set of source files (Ahearn, 1993:227; Arbortext Web Page, 1995).

Secondly, SGML introduces the notion of document type, and document type definition (DTD). Documents are regarded as having types, just as other objects processed by the computers do (Sperberg, 1998). The type of a document is formally defined by its constituent parts and their structure. The definition of a report, for example, might be that it consisted of a title and possibly an author, followed by an abstract and a sequence of one or more paragraphs (Sperberg, 1998).

A DTD performs the function analogous to that of a grammar: it formally defines what are the legal constituent parts of a given markup (Burnard: 1991:9). The demonstration made at SGML'92 Conference is a good example how different DTDs can be created for the same document. In this exercise, five SGML developers created five different DTDs for the literary magazine, *The New Yorker*. This exercise demonstrated the importance of beginning the information reengineering process with specific goals (Ahearn, 1993:228). Sperberg emphasizes the same topic by stating that there is no single DTD which encompasses any kind of absolute truth about a text, although it may be convenient to favor some DTDs above others for particular types of analysis (Sperberg, 1998).

Thirdly, since both markup and content in an SGML document are presented in the basic ASCII character set, SGML documents can be changed easily among most computers unlike other languages (Gilmore, 1993:211; Davidson, 1993:406). This feature is a great strength of the standard and offers the following advantages (Gilmore, 1993:211):

- Markup that identifies information according to its purpose, rather than its format, enables it to be used in multiple applications.

- A single document can be processed in many different ways: formatted for printing, saved to a database, displayed online, or combined with other media for mixed-media displays.
- The use of stored information is open-ended. It can be adapted for hypertext or any other new development that comes along.
- Information does not become out of date when publishing equipment or programs are updated. In fact, information becomes independent of the program that created it.

How Does SGML Work?

An SGML document can be broken into three layers: structure, content, and style. SGML separates these three aspects, but deal with the relationship between structure and content (Arbortext Web Page: 1995). SGML has nothing to do with setting standards for style, so most systems rely on proprietary methods. Two efforts to develop standards-based style sheets have resulted in (Arbortext Web Page: 1995):

- Output Specification (OS), which developed by the U.S. department of Defense under CALS initiative.
- Document Style Semantics and Specification Language (DSSSL), which is developed by the International Standards Organization.

Munguia summarizes how structure, content, style is handled in SGML development environment: “The DTD provides the structure and the FOSI (DSSSL in industry) provides the output format instructions (style) while the “Tagged Instance” provides the content of the final output” (Munguia, 1997:15).

To: Students of SGML
From: Elizabeth Gilmore
Date: January 23, 1993
Subject: DTD for a Memo

A good way to learn about SGML is to use it, beginning with simple documents.

I am sending you a copy of the Memo DTD. Please note that the following structural rules are built into the memo by the element definitions (called declarations in SGML):

- There can be multiple recipients and authors.
- There can be only one date.
- Providing a subject for the memo is optional
- A body must contain at least one paragraph (this element
 - name has been shortened to para)
- Paragraphs can contain one or more list items but these are
 - optional

I hope that you enjoy studying and using this DTD.

Figure 2. The Document Memo (Gilmore, 1993:213)

An example that explains how SGML deals with the structure and content of a given document is given below. As shown in figure 2, a memo document consists of two main parts: header and body. The header has four nested elements within it: recipient, author, date, and subject. The body, on the other hand, contains three levels of nested subelements since paragraph can contain lists and lists can contain items. The tree model of this example is given in figure 3.

Structure: As pointed out earlier, the structure of an SGML document is described by a DTD. (See the sample DTD for the memo example in figure 4). The technical term used in the SGML standard for a textual unit, viewed as a structural component, is element. Different types of elements are given different names, but SGML

provides of no way of expressing the meaning of a particular type element, other than its relationship to the other element types (Sperberg, 1998).

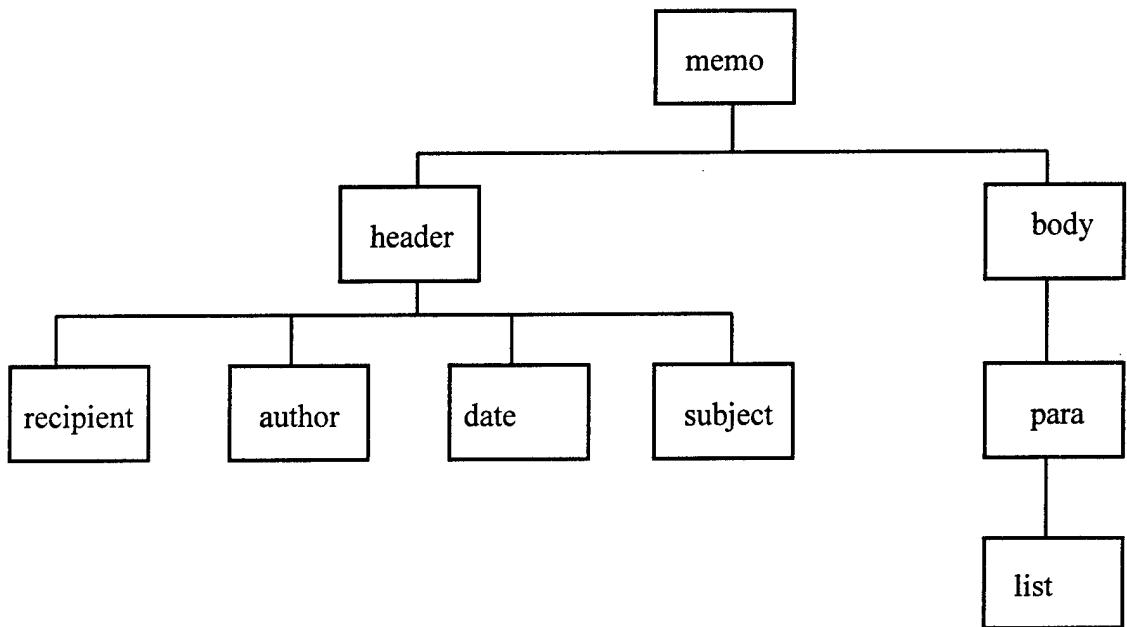


Figure 3. Tree Structure of the Document Memo (Gilmore1993:213)

```
<!DOCTYPE memo (  
<!ELEMENT memo (header,body)>  
<!ELEMENT header (recipient+, author+, date,  
subject?)>  
<!ELEMENT recipient (#PCDATA)>  
<!ELEMENT author (#PCDATA)>  
<!ELEMENT date (#PCDATA)>  
<!ELEMENT subject (#PCDATA)>  
<!ELEMENT body (para)+>  
<!ELEMENT para (#PCDATA 1 (list)+)+>  
<!ELEMENT list (#item)+>  
<!ELEMENT item (#PCDATA)>  
>
```

Figure 4. Sample DTD: Document Type Definition for a Memo (Gilmore, 1993:214)

Each particular document, called a “document instance” in SGML must always be associated with its corresponding DTD in whichever computer system they reside (Gilmore, 1993: 213). (See figure 5). Within a document instance, each element must be explicitly marked or tagged in some way (Sperberg, 1998). Programs called “SGML parsers” analyze and check that the tagging in a document instance satisfies the rules defined by the DTD (Gilmore, 1993:213).

```
<memo>
<header>
<recipient> Students of SGML </recipient>
<author> Elizabeth Gilmore </author>
<date> January 23, 1993 </date>
<subject> DTD for a Memo</subject>
</header>
<body>
<para>A good way to learn about SGML is to use it, beginning with simple documents.</para>
<para>I am sending you a copy of the Memo DTD. Please note that the following structural rules are built into the memo by the element definitions (called declarations in SGML):
<list> <item>There can be multiple recipients and authors.</item>
<item>There can be only one date.</item>
<item>Providing a subject for the memo is optional.</item>
<item>A body must contain at least one paragraph (this element name has been shortened to para).</item>
<item>Paragraphs can contain one or more list items but they are optional (this element name has been shortened to para).</item>
</list>
</para>
<para> I hope that you enjoy studying and using this DTD. </para>
</memo>
```

Figure 5. Memo Document Instance (Gilmore,1993:214)

Content: Content is the information itself. Content includes paragraphs, lists, tables, graphics, and audio. The method for identifying the content's position within the DTD structure is called "tagging". Creating a SGML document involves inserting tags around content (Arbortext Web Page, 1998). Note start and end tags for each element in Figure 5.

SGML Related Standards

XML. Extensible Markup Language (XML) is designed to make it easy and straightforward to use SGML on the Web: easy to define document types, easy to author and manage SGML-defined documents, and easy to transmit and share them across the Web. It removes two constraints, which are holding back Web developments (Flynn, 1998):

- Dependence on a single, inflexible document type HTML
- The complexity of full SGML, whose syntax allows many powerful but hard-to-program options.

The functionality of IETMs would be greatly enhanced if they had the capability of directly accessing the supply and ordering system directly. This capability has been incorporated into a few pilot and production systems; however, there is not a standard mechanism for providing this functionality and data exchange within any IETM or SGML specifications. The current Internet XML initiative will allow the use of XML within existing SGML/XML environments for on-line ordering. (Harvey, 1998)

HTML. Hypertext Markup Language (HTML) is a language which is used to construct documents which can be viewed by World Wide Web browsers. It is a

non-proprietary format, based upon SGML and can be created and processed in a wide range of tools (World Wide Web Consortium Web Page, 1998).

PDF. Portable Document Format (PDF) is the de facto standard for electronic distribution of documents because it keeps the look and feel the user created intact (Adobe Web Page, 1998). PDF files are compact, and cross platform. It is not a markup language; however, it is largely used as an alternative to SGML, especially for the conversion of legacy data into IETM applications. However, PDF does not support the re-use and re-publication of information as easily or as broadly as SGML does (Prettyman, 1996).

On the other hand, U.S. Air Force has chosen to convert the 16 million pages of legacy data (existing TOs) to Indexed Portable Document Format in April 1995(Air Force Product Data Modernization Office Web Page, 1998). The one possible explanation for this is that the costs entailed by conversion may outweigh the benefits expected.

Graphics

In an SGML document, the graphic would be incorporated by reference rather than embedded in the text. This would allow for separate file storage and maintenance, perhaps in a CAD\CAM tool, and production of multiple versions for various delivery systems (Davidson, 1993:405). Thus, graphics and images require their own specialized translation and compression programs (Glushko, 1993:394). IGES, CCITT-G4, and CGM are three graphic standards for CALS compliant data (Bayne, 1989:73; Electro-Tech International Corporation, 1990a:1-2; O'Neil & Associates, 1995b; Knox, 1993).

IGES, which stands for Initial Graphics Exchange Specification, is a standard for exchanging 3-D vector, CAD type data; primarily used for translating engineering drawings into digital form. (Electro-Tech International Corporation, 1990a:1-2; O'Neil&Associates, 1995b).

CCITT is acronym for Consultative Committee on International Telephony and Telegraphy. CCITT-G4 is an international standards body concerned with telecommunications. It is a raster standard used for fax transmissions and scanned images (O'Neil & Associates, 1995b).

CGM, which stands for Computer Graphics Metafile, is a standard that is widely used for all types of technical illustrations. CGM files can include raster graphics, vector graphics, or combination thereof. Although all three graphics are CALS compliant, CGM offers a distinctive approach (O'Neil & Asscoiates, 1995b).

According to O'Neil & Associates, Government and Industry groups throughout the world such as the ATA and CALS are viewing CGM as the ideal companion standard to SGML for integrated text and graphics authoring, management and publishing systems (O'Neil & Associates, 1995b). Munguia also states that CGM is the preferred format for digital TO illustrations in U.S Air Force (Munguia, 1997:19). Harvey explains the ineffectiveness of CALS graphics standards as follows:

IETMs deployed today use various types of graphic formats and styles. Although graphic standards have been specified in several industry standards, including CALS and the Airline Transportation Association (ATA) 2100 most IETMs don't use or support these standard graphic formats. As a result of the ineffectiveness of the CALS standards current IETMs within CALS programs usually use other graphic standards or no standards at all. (Harvey, 1998)

Vector vs. Raster Images

Raster images may come from scanners and paint programs. The key to raster-based systems is that the software package create the illustration by laying down “dots” (turned “on” or “off” to draw the image) to create the image (Electro-Tech International Corporation, 1990a:1-5). Raster images are presented as a matrix, or grid, of tiny black and white dots (300 to 1200 dots per inch). These black and white patterns are represented as binary data. Because both the background and the image must be stored, raster images can be quite large. When raster images are reduced, some of the dots are dropped and the images can lose detail. Enlarged raster images can become jagged and blocky (O’Neil & Associates, 1995b).

Vector graphics systems, such as Computer-Aided Design (CAD) equipment, operate very differently from raster (Electro-Tech International Corporation, 1990a:1-5). With vector images, vector data represents lines, directions, distances, and geometric formulas. The letters and numbers of the type fonts are also represented by the vector data (O’Neil & Associates, 1995b). Thus, vector systems offer the user abilities such as moving an object around or deleting it in its entirety, exploding or shrinking an object, rotating it (especially valuable when operating a 3-D vector system) (Electro-Tech International Corporation, 1990a:1-6).

IETM Development Steps

As discussed earlier in this chapter, IETM development is mainly based on SGML. In the literature, the conversion of legacy data into SGML is called as “up-translation, whereas conversion from SGML into any other format called “down-

translation" (Balise Web Page, 1998; Pepper, 1994; Information Architects Web Page, 1998).

The terms "up" and "down" come from the idea that an SGML document base is designed to model the suitable level of information for a given project. It corresponds to the "highest" level of information. Going from this level of information to any other (publication) structure is therefore a down-translation, whereas going from legacy formats to this level is an up-translation (Balise Web Page, 1998:1).

It is important to remember that every conversion process is different (Information Architects Web Page, 1998). Up-translation can only be characterized on a case by case basis. The number of possible source formats is very large, but among all, an up-translation project is driven by the distance between legacy documents structure and the target SGML structure (Balise Web Page, 1998).

Down translation can be defined and formally specified as a structure-to-structure mapping, because the source of the transformation is a formal (SGML) structure. Down-translation processes, although some of them can be quite complex, are thus very stable and reliable processes (Balise Web Page, 1998). A typical example of "down-translation" is the conversion of data from SGML format into HTML format.

A cross translation will occur when there is an SGML document that uses DTD "A" and now DTD "B" is the preferred form (Information Architects Web Page, 1998).

After this brief broad introduction to "up" and "down" translation in SGML, it is going to be explained what it takes to develop an IETM. However, there is not a formal set of steps. Different sources refer same processes and functions in the development process with different names. In this section, different ways of doing things in the case of

different scenarios are going to be explained instead of trying to find a formal way doing a specific task.

The following discussion about IETM development steps is organized as follows:

- Preplanning
- Conversion Process
 - Input Documents
 - Conversion Itself
 - Enrichment of Technical Information
 - Quality Control
- Database Management
- Deployment

Preplanning

A successful SGML implementation requires forethought and planning in two important aspects, firstly in the specification of general system goals and requirements, and secondly, in the concrete phase of document analysis and DTD-design (Pepper, 1994). Before going to planning and conversion process, it is important to make it sure that the data conversion for legacy information was both possible and affordable (Wood, 1997:27). This task often refer to “proof of concept” (Wood, 1997:27; Information Architects Web Page, 1998; Gross, 1995).

The characteristics possible for an IETM application are limitless, but must be defined prior to beginning the development process (Masincup and others, 1996: 633). Items which must be defined (Masincup and others, 1996: 633):

- Goal of application (instruction, information, reference, or a combination).

- Level of interactivity (text links, graphics links, level of user response, situational simulations, etc.)
- Graphics (line drawings, color, use of three-dimensional models, animations, video, photographs, etc.)
- Simulations, if any (animations, video, sound, etc.)
- Hardware limitations, if any (will existing hardware be used or an new hardware be defined?).

A case study about the Tornado F3 IETM development efforts also identifies the importance of the implications of output specifications in IETM development (Wood, 1997:30). DoD specifies five classes of IETMs, in military projects, according to data format, display, and functionality requirements (Masincup and others, 1996: 633). There is not such a formal classification of IETMs in industry. However, IETM classes developed by DoD is a good reference to be used by industry. This subject is, later, further discussed under the section “Five Classes of IETM”.

Overall, the important thing to understand about SGML applications is that they are not all the same. There is actually no such thing as “converting to SGML”, only converting to a specific application (Grosso, 1998).

SGML applications are always based on a specific DTD. Here are the some of the question should be asked while developing a DTD (Grosso, 1998):

- What kinds of document exist, and what common classes of documents can be identified?
- What are the basic structural components and other logical objects that occur within each document type?

- In addition to text content, what other information or properties might be assigned to each object type?
- What are logical relationships between each of the objects?
- What do you want to do with your information? What are the kinds of structures and relationships that you are wanting to encode in SGML in order to drive electronic document delivery, document management, and other benefits that are motivating SGML conversion in the first place?

The analysis of legacy data is performed to determine what kind of format the initial documents are in (Severson, 1998; Pepper, 1994). This task involves matching up the input to the kinds of information elements and relationships assumed in the SGML application. In this case some of the questions that should be asked are (Severson, 1998):

- What form(s) input at hand (hardcopy or electronic, etc.)? What are the graphics, equations and other formats that may need additional conversion?
- How “structured” is the input? That is, how much explicit encoding of structural objects, row/column tables, links, etc. is already available? How consistently have these conventions been followed?
- How do the “objects” (visually or explicitly encoded) in the input document relate to the objects in the target SGML?

Conversion Process

According to Gross, conversion is an important issue because you are rarely starting anew (Gross, 1993:219).

Input Documents. The form of the input can make a big difference in the selection of suitable conversion approach. Figure 6 represents information in different forms. The higher in the chart, the more effort is required to infer the information for SGML conversion (Gross, 1993: 221).

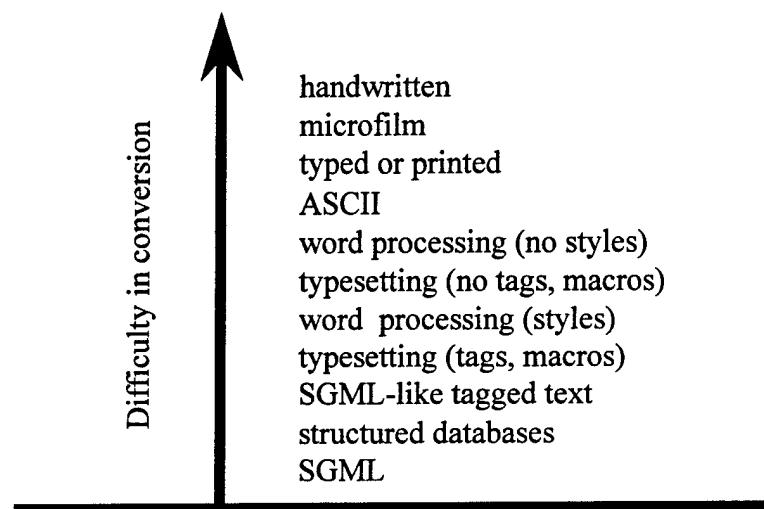


Figure 6. The “Ease of Conversion” Hierarchy (Gross, 1993:219)

Severson says that hardcopy is the hardest place to start (Severson, 1998). The first step in converting hardcopy to SGML is getting text into digital form. This can be done by manual rekeying, or automated by Optical Character Recognition (OCR) scanning. According to a case study done by Army, accuracy rates of 99+% are reasonable targets and obtainable with OCR scanning (Electro-Tech International Corporation, 1990b:4-2). With hardcopy documents, all structure is visual. There is no underlying encoding to translate to SGML. OCR errors can multiply the effect of errors in the conversion process (Severson, 1998). Therefore, for all scanned materials you must have a human review (Gross, 1993:223). Graphics and equations are available only in raster format and have their own set of parallel conversion issues (Severson, 1998).

Conversion to SGML is a lot easier when input has been authored in electronic form (Severson 1998). The advantage of using electronic formats, even those “ugly” typesetting formats, is that the text will transfer accurately, and if the tapes are correct, the text accuracy is 100% (Gross, 1993:223). However, electronic format is deceptive (Severson 1998). The way in which material is coded is not necessarily the way you would have expected, and therefore the document will not necessarily convert the way you expect that it should (Gross, 1993:223).

As discussed earlier, sometimes systems requirement may necessitate the conversion of data from a DTD to another DTD. These kinds of conversions may be simple or complex depending upon DTD that the data is in and which DTD the data is being transformed to (Information Architects Web Page, 1998).

While creating an IETM from scratch, data should be authored in SGML. In SGML authoring, the basic operation consists of building a structure from object identifiers (tags) or typing into a predefined element structure (Davidson, 1993:405). With the first case, a standard character-based editor such as some word processor in “ASCII” mode to author both text and markup can be used; whereas with the second case an SGML-aware editor provides automatically or through some non-character based interface the proper markup (Grosso, 1998).

Overall, while selecting source materiel it is important to take into account (Gross, 1993:222-223):

- The ease of conversion
- The accuracy of the information
- Version integrity

- Text integrity

Conversion. The text portion of a document contains three categories of information, in order of increasing conversion difficulty (Gross, 1993:221).

- Data, text and numbers- are relatively easy convert automatically.
- Structural information-is inferred from the structure of the document.
- Content-based information- requires an understanding of the topic area

Figure 7 depicts various components of typical documents. Each component blends of the three types of information, and is dealt with in a different manner (Gross, 1993:222).

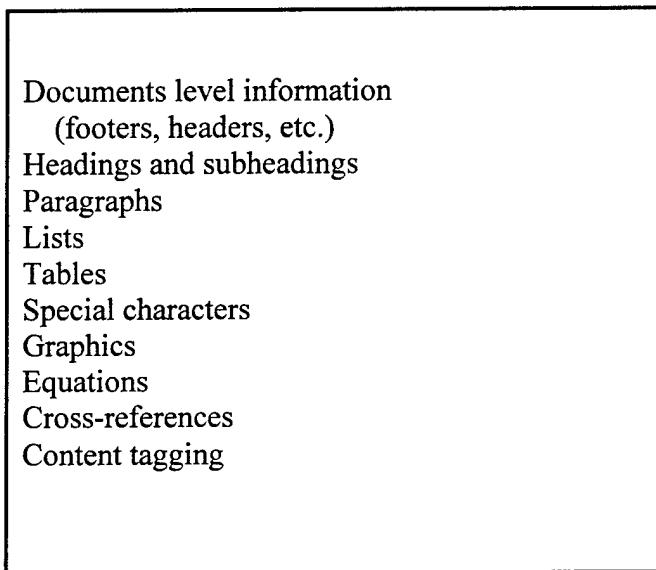


Figure 7. Various Components of Typical Documents (Gross, 1993: 221)

The primary aim of the conversion process is to make explicit structure, which already exist implicitly in the source document. The kinds of structural clues that may be picked by and used by an up-translation system are threefold (Pepper, 1994).

- Visual attributes: Elements can be differentiated from one another by the way they are placed on the page. For example, paragraphs may be separated by blank lines or marked by first line indents.
- Generic codes: Documents that come from a text processing system may already contain some form of generic markup that offer clues as to their structure. For example, chapter heads may be encoded as “\chapter” {Title of chapter} in a TeX.
- Textual patterns: Some elements may be recognized on the basis of recurring textual patterns. For example, a chapter heading may be preceded by the word “Chapter” followed by a number.

It is quite often that common production techniques are not viable due to different publishing techniques have been used over years (Wood, 1997:28). Getting data into SGML may be achieved in number of ways (Pepper, 1994):

- Direct authoring
- Keyboarding from a manuscript
- Generating from some other structured source, such as a database or spreadsheet
- Scanning from a printed source using optical character recognition
- Translating from an unstructured electronic source

In general conversion can be either manual or software assisted (Severson, 1998; Gross 1993:222). Figure 7 illustrates the cost of conversion with respect to manual and automated conversion. As can be guessed from the figure, there is an overhead (initial cost) to set up automated conversions, whereas variable cost drops quickly.

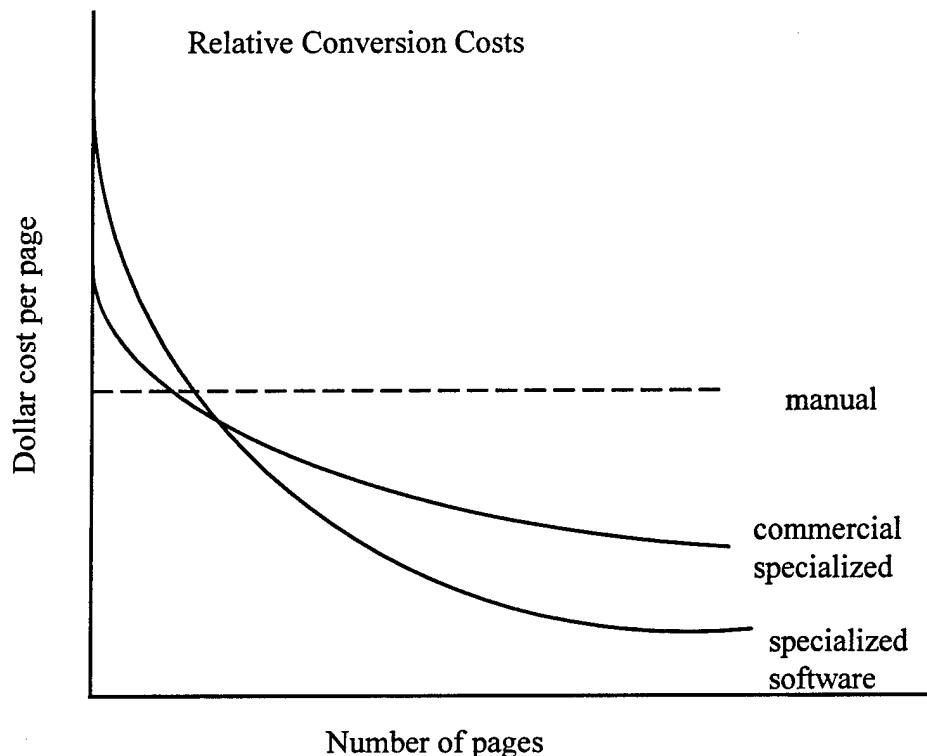


Figure 8. Chart for Relative Conversion Costs (Gross, 1993:221)

Enrichment of Technical Information. SGML is one of the most prominent among those languages that are being used to “mark up” documents to insert information in the documents in addition to the normal text (Sengupta, 1998). IETM may present the user different kinds of data that are not available with conventional paper manuals. As discussed in Chapter I, Conway categorizes problems with paper manuals into three groups. One group is the difficulty in finding and understanding the technical information. According to Conway, only way to solve this problems is the hypermedia (Conway, 1990), and IETMs are based on hypertext and hypermedia (Rivera. 1998). You can enrich technical data in a variety of ways by using hypertext and hypermedia such as by adding pop-up menus, audio files, and video files. You can add data base hooks to other related information such as other databases, and complementary information (warranty, and service information etc.). Hypertext and hypermedia

information which may explicit or implicit in technical data must be captured in document analysis.

A report prepared for DoD summarizes and differentiates IETM data into two groups. First group includes different types of technical data, whereas second group includes types of information related to the use of IETMs, but not part of the content (Delivery and Presentation Committee, 1991:3-1).

1. Technical data itself

- Diagnostics/Fault Isolation. Automatic and manual trouble shooting and fault isolation, battle damage assessment, including expert systems
- Procedural. Remove, replace, checkout, checklists, operating instructions, fault isolation
- Descriptive. Theory, principles of operation
- Precautionary. Warnings, cautions, notes, safety summaries
- Graphics
- Parts. Parts numbers, reference designators

2. Types of information related to the use of IETMs, but not part of content.

- Indexing. Menus, lists of contents, and key words
- Identifiers (ID). Titles, classifications, and numbering
- Look-up tables
- Maintenance and operations management. Data collection, feedback, scheduling, and audit trails
- Glossary
- On-line help

- Built-in-test data from prime or test equipment

Quality Control. All SGML authoring systems must include a parser (Davidson, 1993:407; Gilmore 1993:213). One of its uses is validation and checking, and it enables the user to validate that the document conforms to rules of its DTD and to the rules of SGML itself (Davidson, 1993:408). The ISO technical report TR10037 (1991), as also discussed by Davidson, distinguishes among static, dynamic, and partial validation (Davidson, 1993:408).

- Static validation means checking for errors “at the end of the creation or modification process or on specific user request.”
- Dynamic validation means that the user is guided by the program in the editing process in such a way that errors may not be inserted.
- Partial validation allows the user to begin document creation at the paragraph level and still have the benefit of validation for the paragraph without the parser prompting for missing chapter tags or require chapter title.

According to Severson, against the common belief quality control is synonymous with SGML parsing, there are, actually, at least three critical dimensions of quality control (Severson, 1998:9):

- Syntactic correctness: making sure it parses,
- Semantic correctness: making sure tags actually correspond to the correct objects, with beginnings and ends at the correct spots,
- Tagging completeness: making sure any information that is important to the document is not missed

Database Management

The trend in technical documentation systems is toward a database management approach where information is organized and managed as logical units (Waldt, 1993). Increasingly SGML data is being stored in databases, where access to the stored data is being controlled at the levels below of that of a complete file/document/message (ISO/IEC JTC1/WG4 N1946 Web Page, 1998). At the conceptual level database systems can be distinctively categorized under the following three generations of database systems (Sengupta, 1993):

1. First Generation: Hierarchical and Network Databases
2. Second generation: Relational Databases
3. Third generation: Object-oriented, Object-relational databases

In terms of data storage and information management, users seem to have three choices - they can stick with the established, performance-optimized relational databases, opt for the emerging (but still untested) capabilities of object oriented database systems, or take a middle path by buying a hybrid database (McNamara, 1998).

Relational databases are excellent at handling (storing, retrieving, and analyzing) alphanumeric data. They are not as adept at handling variable length data, such as text, scanned images imported from paint or drawing programs, or large bitmap images CAD\CAM files (Dewire, 1994:114). In addition, SQL, the industry standard retrieval language for relational databases, can not manipulate binary large objects (BLOBS). On the other hand, object-oriented databases are beginning used to effectively store and retrieve BLOBS which are used much more, especially in multimedia (Dewire 1994:114).

According to McNamara, although not specifically technical, a technology strategy that is inclusive - one that employs Object-Oriented document management functionality layered on a conventional relational database is the best approach to store and manage the information in databases (McNamara, 1998).

Class 4 and class 5 IETMs , as it is discussed under “Five classes of IETMs” section, require the use of databases to manage the information (Jorgensen, 1994: 6-7). Wood gives a good example of database management in Tornado F3 project. The project uses an SGML-based data module concept complying with European Aerospace Documentation Specification (AECMA) 1000D (Wood, 1997:29). Information Codes defined in the AECMA 1000D specification identify the type of information contained within the data module- servicing, examination, failure, reporting, repair, removal and installation, storage etc. Each module can be put into, and retrieved from a database using a data module code (DMC) as identifier.

Deployment

The deployment is the last stage of producing an IETM development. The information which is in SGML format should be delivered to the end-user. It may be delivered in SGML format, HTML, other markup languages, or word documents. Pepper identifies three different deployment categories (Pepper, 1994):

- SGML based systems- the software directly operates on the SGML document itself. Such systems will usually employ some standardized way of specifying how to apply processing to the document type, e.g. using a FOSI or methods defined in ISO 10179 (DSSSL).

- Quasi-SGML systems – these systems do not directly operate on the SGML instance itself, but are able to import and export SGML documents to and from the system’s own internal representation.
- Non-SGML systems- the using software that knows nothing at all about SGML itself is the most common way of laying out SGML documents. In order to use non-SGML systems, the SGML documents must be transformed into a different notation such as a specific markup, or proprietary “tagging language” associated with a desktop publishing program.

A wide variety of tools can be used for displaying SGML data. Generally, they fall into three classes (Conrad, 1998):

- Readers: are used to display the contents of files without any interpretation or rendering.
- Viewers: add interpretation and rendering capabilities but base most of their rendering on metadata (formatting codes) which were designed to support the printing of paper hard copy.
- Browsers: abandon the page metaphor to provide an electronic delivery environment that is more in tune with the capabilities and constraints of computer displays.

In IETM development environment, the most popular forms to deploy IETMs to the hands of user are in a CD-ROM or on World Wide Web (WWW). Both technologies and the tools using them are rapidly increasing in functionality and accessibility and this, in turn, continues to expand the types and numbers of applications developed in IETM development environment as well as in most areas of our life (Kribs and Mark, 1995).

There are important differences (pros and cons) between these two channels for deployment of IETMs.

CD-ROM publishing and viewing software requires some sort of licensing cost and legal arrangement for distribution. Hardware is another issue. Designing a CD for multiple platforms such as PC, Mac, and Unix may require the help of a consultant specializing in system migrations. On the other hand, one advantage to CD-ROM over on-line publishing is that it is not restricted to the logical structure inherent in Hypertext Markup Language (HTML). Moreover, there are more formatting options available on CD-ROM and production is ideal for large and complex projects that contain elaborate tables, equations, and formatting structures (O'Neil & Associates, 1997c: 2-3).

The WWW publishing allows the user easy access to information. TCP/IP (Transmission Control Protocol/Internet protocol) allows for seamless integration with all system platforms. Thus, issues concerning individual access, network access, platform compatibility and licensing fees are no longer factors. Both data and interface can be modified very quickly with online publishing. Hence, the target audience receives the latest data. Unlimited worldwide resources can be incorporated in the publications by simply providing links to them and distribution costs are eliminated (O'Neil & Associates, 1997c: 2-3).

Five Classes of IETMs

The variances in electronic presentation form and the ranges of embedded functionality have resulted in a very broad spectrum of electronic technical manual implementations making discussion and comparison of alternate systems and approaches difficult (Navy CALS Web Page, 1998). Tri-Service Working Group for IETMs

developed five classes of technical manuals for DoD with the proviso that it be used for definition only and not as an specification for procurement. These five classes of IETM are explained below (Jorgensen, 1994:2-7):

Class 0.

Non-electronically-Indexed Page Images (Not an ETM) - "Systems of Digitized Page Images that are intended for electronic archival filing or Print-on-Demand. These allow pages to be viewed on an electronic display but have no detailed index for navigation through the document for purposes of on-line usage. (Page 4).

Class 1.

Electronically Indexed Page Images - Systems of Digitized Page Images intended for Full-Page Display and use allowing navigation by means of an automated intelligent index to the page images for user access (Jorgensen, 1994:4-5). The primary purpose of the technical manuals in this class is to print a paper manual on-demand and thus eliminate the need to stock the paper manuals before they actually needed (Villecca, 1997:15).

Class 2.

Electronic Scrolling Documents - Systems for Interactive Display of ASCII encoded Documents using an intelligent index and Hypertext tags inserted into tagged document file. In general, the document is the result of a simple conversion from a page-oriented document but with little reauthoring with the exception of adding hypertext tags (Page: 5).

Class 3.

Linear Structured IETMs – Interactive Display of technical Information which is SGML tagged using MIL-D-87268 tags to the maximum extent possible and using a Hypertext presentation system for display in accordance with MIL-M-87268. Class 3 is the class in which the TM authoring organization has an opportunity to reorganize for electronic presentation, augment and convert an existing manual into an IETM data-element form in order to increase technician performance by better access and display of information, as well as, provide the benefits achieved by eliminating paper (Page: 5-6).

Class 4.

Hierarchically Structured IETMs – Interactive Electronic Display of Technical Information specifically authored into and maintained in a non-redundant relational or object-oriented hierarchical database. These source data are subsequently packaged (i.e., “view packaged”) as a run-time database for Interactive Presentation in accordance with the DoD IETM Specifications (MIL-M-87268, and MIL-D87269). Class 4 Systems (IETM) are those for which the TM data was specifically authored into a non-redundant hierarchical data base form, using a data base management, system for the total content (Page: 6).

Class 5.

Integrated Data-Base IETIS – Integrated Electronic Technical Information System (IETIS) for Interactive Presentation of Class 4 IETMs integrated in with the data for other processes including Expert-system rules for the display of information and other user-applications such as diagnostics or computer-managed training (Page:6-7).

To summarize interrelationships between these five classes, at the user-presentation level, Classes 3 through 5 can show almost identical features. However, Classes 1 and 2 are after-the-fact preparation systems while classes 3 through 5 involve technical manuals prepared or reauthored by the authoring organization. Classes 1,2 and 3 involve encoding a linear document with its existing section after section structure, whereas Classes 4 and 5 employ the use of information extracted from a managed hierarchically structured database and compiled into a form optimized for interactive screen presentation (Jorgensen, 1994:7).

These five classes are tabulated at table to according to their features in the areas of display, data format, and functionality at Appendix C.

IETM classifications should not be considered as constraints on a development process. It is more advantageous to begin by defining the functions needed in a specific IETM and tailoring the development process to the need rather than selecting a class that may or may not meet application needs (Masincup and others, 1996:632).

Today's IETM Environment

As with any new technical product, the standards are continually being defined, making it difficult for published requirements to keep pace with changing definitions (Masincup and others, 1996:632). Some problems areas identified by industry and military are related to obsolete standards and lack of standards. Here are some examples how military and industry see the problems areas in the IETM development environment. As also discussed in “graphics” section, Jorgensen identifies the inefficiency of IETM standards:

IETMs deployed today use various types of graphic formats and styles. Although graphic standards have been specified in several industry standards, including CALS and the Airline Transportation Association (ATA) 2100 most IETMs don't use or support these standard graphic formats. As a result of the ineffectiveness of the CALS standards current IETMs within CALS programs usually use other graphic standards or no standards at all. (Harvey, 1998)

The largest customer (DoD) for IETM development projects are not without problems. Jorgensen identifies problems in DoD as follows:

As the use of IETMs became more widespread, it became important to establish an infrastructure to manage and distribute IETM updates to multiple field sites and to provide life-cycle support for numerous IETMs. In this environment, the fact that differing IETMs cannot interoperate (i.e., cannot be viewed on the same standard presentation system, or electronically reference each other to any meaningful level of internal granularity) has become a major impediment. (Jorgensen, 1998)

There are some concepts to encounter the challenges in today's IETM development environment. Two of these concepts are Interoperability, and STEP. Interoperability is mostly emphasized in military, whereas STEP is more general concept. STEP concept is discussed below; interoperability concept is left for a further research though.

The Standard for Exchange of Product Model Data (STEP)

Today, product design and product documentation are totally separated processes and there is practically no automated information flow between these two domains. The integration of the data associated with a product and its documentation is a primary step toward the enterprise-wide information systems that are needed by industry today

(Electronic Commerce Connection, Inc. Web page, 1998). Product data and product documentation terms are defined as (Electronic Commerce Connection, Inc. Web Page, 1998):

Product data carries essential information about the design, manufacture, operations, etc. of the actual production of an enterprise. Most product data is created and used early in the life cycle of a product such as the phases of design, analysis, and manufacturing.

Product documentation describes many aspects of a product: its design, use, maintenance, disposal, etc. Most product documentation, for example training, maintenance, and operation manuals are created in the later phases of a product's life cycle. Product documentation uses product data as the primary source of information.

Mr. Holloway, the Air Force representative in Tri-service ITEM working group, agrees that ITEMs are used in supporting maintenance and training, whereas STEP concept compromises of design, manufacturing, maintenance and support, and training for a given product (Holloway, 1998).

The combining of product documentation into the total life cycle of manufactured products allows more effective, timely, and accurate descriptions of the product and is profitably reflected in many parts of a product's life-cycle (Electronic Commerce Connection, Inc Web Page, 1998).

STEP is an ISO standard (ISO 10303) whose goal is to enable a product representation to be exchanged without any loss of completeness (Commerce At Light Speed (CALS) Web Page, 1998). The STEP/SGML initiative will provide a mechanism for information objects coming from the STEP environment to be used within all

technical manuals. Creation of the information object early in the design manufacturing process will ensure that the information is correct from a design and engineering standpoint. The information objects can be used within paper manuals, IETMs, Computer Based Training, etc. (Harvey, 1998).

III. Methodology

Introduction

The case study of Intercept project, between O'Neil & Associates and Cummins Engine, was undertaken to investigate IETM development process in a civilian environment. IETM development process steps, management issues that contributed to the project's success, and different implementation issues that made Intercept project different from general applications are discussed.

This chapter details the research design employed, methods used to gather data and problems to be possibly countered in finding answers to research questions posed in Chapter I. Different Knowledge Acquisition (KA) techniques, KA problem areas and the unstructured interview technique are discussed.

Research Design

Developments in computer and electronic technology in last two decades made the use of digital data available and preferable. First initiatives to utilize digital data came from military. Although, much has been written about IETM development and its advantages in military sector, little research has been done in civilian environment, especially, in the area of IETM development.

Since this study emphasizes what IETM development process steps are, how the work is done in each step, why some alternative methods and techniques preferred over others in Intercept project, the case research method is the best research method for this undertake. Yin summarizes relevant situations for different designs (Yin, 1994:6).

Table 1. What Questions are Relevant for Each Research Strategy? (Yin, 1994:6)

Strategy	Form of research question	Requires control over behavioral events?	Focuses on contemporary events?
Experiment	How, why	Yes	Yes
Survey	Who, what, where, how many, how much	No	Yes
Archival analysis	Who, what, where, how many, how much	No	Yes/No
History	How, why	No	No
Case study	How, why	No	Yes

The case study research design is chosen as best suited for this effort. Leenders and Erskine express the need for new case studies:

“New problem areas, new theories and new subject approaches need to be exposed” (Leenders and Erskine, 1989:2).

Yin emphasizes the importance of case studies:

“The case study allows an investigation to retain the holistic and meaningful characteristics of real-life events” (Yin, 1994:2).

He believes that the following areas given below are well suited for case study. (Yin, 1994:2).

1. individual, organizational, social, and political phenomena
2. psychology, sociology, political science, and economics
3. organizational and managerial processes
4. international relations and maturation of industries.

The researchers believed that the research effort undertaken is well corresponded with *organizational and managerial processes* for the purpose of this case study.

Unit of Analysis

Unit of analysis refers to the problem of defining what the “case” is. A case may person, a group of people, an event or entity (Yin, 1994:20-21). In this study, the case is Intercept project between O’Neil & Associates, IETM developer, and its customer, Cummins Engine. The study intends to expose IETM development process in Intercept project, and to include situational factors such as the level of relationship between customer and contractor, that affected the project success.

Knowledge Acquisition

The process of eliciting knowledge from experts in field to support decision support systems is called Knowledge Acquisition. Knowledge Acquisition activities can be divided into five steps (Byrd and others, 1992:119). First step, *identification step*, is the establishment of communication between the Knowledge Engineer (KE) and the expert. In second step, *conceptualization*, KE interprets data to draw conclusions about the underlying knowledge of the expert. In third step, *formalization*, KE establishes a model that represents the expert knowledge and processes by using his or her knowledge. Fourth and fifth steps are *implementation* and *testing*, respectively, but these two steps are not valid for the purpose of this study since the study is not intended to directly use acquired data in field.

Before starting a new project in business or in private life, it is important to know problems and risks that are likely to occur in project life cycle. Knowing them will

increase the understanding of environment and probability of success. Communication obstacles that affect success of a Knowledge Acquisition as well as Requirement analysis studies are divided into three categories (Byrd and others, 1992:122-123): WITHIN, BETWEEN, AMONG obstacles.

WITHIN obstacles are the results of cognitive limitations of human being. As, human beings, experts as well as knowledge engineers are limited in understanding natural phenomena and in processing information due to cognitive shortcomings.

BETWEEN obstacles are results of cognitive shortcomings with the expert and the Knowledge Engineer, and lack of common language between them. Experts and knowledge engineer are with different backgrounds and with different mind set (Byrd and others, 1992:122).

Although above two obstacles types are minimized as much as possible, there is one more obstacle type, namely, AMONG obstacles, that should be taken into consideration by the analyst. AMONG obstacles are associated with the determination of information needs of users. Increasing number of users means increasing number of different data needs that should be balanced in the study by analyst.

Data Collection

In case studies data may come from different sources. Yin summarizes these sources in six categories, three of which were used in this study. These are, namely, interviews, participant-observations, and documentation (Yin, 1994: 79).

O'Neil & Associates was contacted through Tom Milligan, the head of the marketing department. O'Neil & Associates has been developing different types of technical manuals since 1947. After the company informed its willingness to cooperate,

a document that explained the purpose of the study as well as the research questions and expected details thereof were submitted to the company. Research questions developed by researchers can be categorized into two categories. First category questions emphasize general applications in IETM development process for different situations, whereas second category questions emphasize issues that are specific to Intercept project, on which the case is based. These research questions are given at Appendix D.

This document was important in getting the permission of Cummins Engine because of concerns about revealing of confidential information. After the approval from Cummins Engine as well as O'Neil & Associates, the researchers made weekly interviews with O'Neil & Associates. Interview schedule emphasized management issues up-front, and process issues in the logical order later. However, interview schedule affected by the companies' schedule as well as individuals' availability.

In this study, open interviews were employed as the main Knowledge Acquisition technique. The greatest advantage of interviews lies in the depth and detail of information that can be secured (Cooper and Emory, 1995:271). They provide relaxed environment, in which analyst may control the proceeding of Knowledge Acquisition by probing with additional questions and by adjusting the language of the interview. It will increase the quality of the data gathered. As a result, they can help move aside BETWEEN obstacles (Byrd and others, 1992:130). Interviews questions followed from the research questions were developed to investigate important issues mainly in two areas, namely, IETM development process and situational realities that affected the success of the project.

Observation and documentation were the other sources of the study. When the subject under discussion were hard conceptualize, the researchers requested to observe relevant process where applicable. Moreover, the final product and its functions on Internet browsers were also observed. O'Neil & Associates' managers provided documentation about the previous works they had done, about the processes in the company, and about standardization they employed. The documentation provided helped to understand general processes, and standards employed, thus giving chance to researchers to compare Intercept project to other projects.

Summary

The methodology used in this study is mainly qualitative in nature. The case study design is used to gather information. The primary method to gather data is the personnel interviews with O'Neil & Associates' personnel. Knowledge acquisition techniques as well as communication obstacles between researchers and experts are also discussed in this chapter. Observation and documentation provided by O'Neil&Associates are the other sources of information for the study.

To get permission of O'Neil & Associates, Inc. to make the case study, a document was prepared that explained the purpose of the study as well as research questions and detail thereof. The research questions on this document are given at Appendix D. The following chapter, Chapter IV, discusses the case itself.

IV. Case Study

Introduction

This chapter will present the analysis and findings of the research effort. As stated in prior chapters, the purpose of this thesis was to conduct a case study on the development of an IETM in the commercial environment. The focus of this chapter will be on how certain steps of IETM development that discussed in the earlier chapters were implemented in this specific case, what factors were taken into consideration in commercial environment, what were the problem areas, and how they were handled.

Background

Over a number of years Cummins Engine Company has produced numerous engines for the commercial environment. O’Neil & Associates, Inc. has been writing both paper manuals and IETMs for the company since 1996. The IETM development project, named as “Intercept” by O’Neil & Associates, Inc. is the development of a CD-based information system containing 20 different types of manuals, 2000 interim update documents, Customer Assistance Center Frequently Asked Questions, and the customer’s Insite Fault Information System. The CD set contains more than 15,000 pages of technical information, including Troubleshooting & Repair, Operation & Maintenance, Warranty Information, and any interim field notifications, which may impact the service history of a database of more than 250,000 engine serial numbers (ESNs) produced by the manufacturer. More than 16,000 illustrations are stored in a graphics database as GIF files which are automatically dropped into place when the appropriate file is displayed.

Key product features include documents tied to engine serial numbers or configurations; information based on the users' role or function and accessed from an interactive table of contents; improved troubleshooting navigation; enhanced procedural text; and on-line help and user manuals with printing capabilities.

Is an IETM Really Needed?

The decision to develop an IETM was made by the Cummins Engine Company as a result of looking for a way to improve delivery of service information to a variety of users. Estimates by the company showed that, for manuals only, annual paper output would increase from 18,000 pages in 1996 to 28,000 pages by the end of 1997. In addition, Cummins published over 500 interim documents per year with varying levels of distribution and security. The company expected to make the information more timely, accurate, and accessible by using electronic format. The purpose was faster troubleshooting and quicker repair guides in a much smaller, easier-to-use package.

In spite of all of their expected benefits, IETMs have been proven to be more costly than paper manuals, at least at the beginning (Holloway, 1998; Munguia, 1997). This result is likely to be caused by high initial costs compared to low life-cycle costs. Main cost drivers can be stated as the cost of electronic equipment required to use the IETM at the beginning and the cost of creating digital files. This cost structure does not change even if there are existing paper manuals because of the high cost of the conversion process (Milligan, 1998). In addition, these manuals require a complete change not only in manual development process but also in technical procedures such as service, maintenance, trouble-shooting, and record keeping. As a result of these facts, IETMs are mainly preferred by big companies like weapon systems or airplane

manufacturers, or required by government agencies in their contracts. In most of the cases either the agency has the support (or requisition) from the government or has its own service web and a huge budget. Being in a pure competitive and highly customer oriented environment, primary issues that Cummins had to consider before beginning such a project were slightly different from the other cases. Number one driving force in identifying the scope of this project was the customer response. Customers of the company at 26 different countries were used to their traditional way of doing job for years. This fact influenced the company's decision to continue producing and distributing paper manuals and presenting IETM as an additional service. The wide range of customers with a wide range of technical skills and capabilities was another problem and forced both parties to keep the requirements as simple as possible at the requirements analysis phase.

Development of an IETM

As a data sub-contractor, O'Neil & Associates, Inc. is implementing a program management approach in its contracts. A senior specialist within the organization is appointed to organize the program internally. This project manager assumes full responsibility for quality, technical content, schedule, format, and customer acceptance. The general method of operation can be written as follows;

1. Upon award of a contract, a meeting between Company's Program Manager, applicable project managers, and the customer is held before any work commences. In this way, individuals from both organizations develop a mutual understanding of the methods and the practices to be followed.

2. The managers analyze the contract requirements, define the scope of each project, plan the effort, and enter the man-hour loadings for each discipline and the critical dates for each task into the company's computer system.
3. Each project manager reviews the available source material. He/she works with the customer to define the optimum methods of collecting and developing the other necessary information.
4. Writers and catalogers study the source data, write the text, and define the illustrations. They schedule and conduct interviews with the design engineering staff as needed. They also examine and operate the equipment to ensure that the procedures are correct and easy to follow.
5. As the program develops, in-process reviews with the customer check whether all milestones are being met and that the work meets the customer's requirements.
6. Official validations, conducted by writers and their project managers, are done to provide the accuracy and usability of each procedure.
7. Closely-managed tracking and incorporating of engineering changes are tried to be managed to ensure that all publications are current.
8. After pre-publication review by the customer, final products are produced.

In addition to this general approach, IETM development requires additional planning and additional steps depending on its characteristics. Prior to initiating any consideration of an IETM project, it is imperative that two actions be completed: 1) attain a solid functional understanding of what an IETM is, and 2) clearly define the goals and expectations for the specific application (Masincup and others, 1996:632). You may

have to view more than a dozen IETMs before these items are solidly in your grasp, and, with it, a solid foundation for your project. In addition, a process for the development and maintenance of the IETM must be clearly defined (Masincup and others, 1996:632). Basic steps implemented by O'Neil & Associates in this IETM development process are identified as follows:

- Preplanning
 - Requirements Analysis
 - Document Analysis
 - DTD Selection
- Project Planning and Scheduling
- Conversion Itself
 - DTD Conversion
 - Hard Copy Conversion
 - Electronic Form Conversion
 - MS Word
 - Xyvision
 - Graphics Conversion
 - SGML Finalization
- Data Enrichment
- Database Management
- Production Process
- Quality Assurance
- Final Product

Preplanning

The characteristics possible for an IETM application are limitless, but must be defined prior to beginning the development process. Items which must be defined are:

- Goal of the application (instruction, information, reference, or a combination).
- Level of interactivity (text links, graphics links, level of user response, situational simulations, etc.).
- User controls and interface (cuing, “buttons”, windows, etc.).
- Simulations, if any (animations, video, sound, etc.).
- Graphics (line drawings, color, use of three-dimensional models, animations, video, photographs, etc.).
- Sound, if any.
- Hardware limitations, if any (will existing hardware be used or can new hardware be defined?) (Masincup and others, 1996: 633).

All of these items must be identified in the preplanning step and mostly in the requirements analysis phase.

Requirements Analysis. Various classes of IETM have been defined dependent upon their interactive functionality. However, these classifications should not be considered as constraints on a development process. It is more advantageous to begin by defining the functions needed in a specific IETM and tailoring the development process to the need rather than selecting a class that may or may not need application needs (Masincup and others, 1996: 632).

The requirements analysis step implemented in this project can be divided into two parts, which mustn't be an extraordinary application in competitive commercial

environment. First part included prioritizing basic product functions and features and was done by different entities allowing them to estimate the cost of the project and make their offer to the company. Second part completed the requirements analysis phase in detail and was done by the contracting (IETM developer) company after the agreement was reached between parties.

First Part: Initial Analysis and Offer. First part of the analysis began as a common process. The customer wanted an electronic database and an interactive, windows-like format. There were two main candidates for this process. Robert Heilman, O'Neil's Director of Technical Operations, and other O'Neil staff met for two weeks with Kevin Otto, Director of Service Publications at Cummins Engine Company, additional Cummins employees, and representatives of other candidate IBM/ISSC to define a system which had the required functionality. The group suggested and prioritized product functions and features before agreeing on a set of criteria.

System requirements were identified according to the Cummins' customer structure. The company had several clients that were not electronically advanced, so they wanted a system with minimum requirements. They wanted the system to run at least on 386SX type personal computers with Widows 3.1 operating system. This was the first problem for the O'Neil & Associates, Inc. because O'Neil was using Java as search engine and Windows 3.1 did not support this language. Customer also wanted the output information to fit any kind of display units with 640*480, 800 *600, or 1024 * 768 resolution. The program had to work on a LAN server, Internet, or a local drive, and had to be accessible by most common browsers Internet ExplorerTM and Netscape NavigatorTM.

At the end of the period, the group agreed on a set of criteria. The system would show a number of manuals and interim documents, based on the user's search criteria, and could run on a personal computer system of 486DX with a minimum speed of 33MHz and 8 megabytes of random access memory (RAM) using Windows 3.1 operating system. Users would navigate the software with buttons which emulated those in Windows and could print documents using the browsers' "Print" function.

IBM/ISSC quoted the program development cost at \$2million for two years' work. Cummins rejected that bid. O'Neil & Associates pledged to do the work in half the time at half the cost. Cummins accepted O'Neil's bid, and the project advanced to its second step.

Second Part: Detailed Definition of Requirements. There are numerous considerations when embarking on an IETM project, and little written guidance to follow. Some of the items that are highly desirable prerequisites to the initiation of IETM development can be stated as follows:

- The technical content for the system is mature and well documented or this is a new system where all material will be prepared from the onset to IETM requirements.
- The IETM developer is familiar with the selected IETM software and end-user target audience.
- The IETM product is clearly defined based on customer expectation and concept of use including the operating platform (hardware) requirements.
- The project team consists of individuals experienced with IETM design, development, and production.

- The customer is part of the design team.
- The customer has objective written acceptance criteria.
- The quality assurance plan and organization are in place.

O'Neil identifies the requirements analysis step as the biggest and the most important part of the project.

...you could spend a month doing requirements analysis thinking you are going to do it this way and then you will come across something that, a piece that just doesn't fit and you will have to back all the way out almost to the beginning and then take off in another direction. So requirements analysis and preplanning phase is where you have to be the most flexible and it takes the longest time. (Evans, 1998)

The company tried to solve this problem by making the customer a part of the design team and keeping the design team as big as possible, since bringing more people together would bring in different ideas to it. First meetings of the team were held as brainstorming meetings. Team members had pieces of paper and wrote down one of their responsibilities, and continue doing that until they had written everything they had thought they were responsible for or needed to do. Then they took those pieces of paper and placed on a big, poster board, where they thought they belonged in the flow. It was amazing for the team members to see the amount of pieces that they were missing in the analysis. Every piece of paper was telling what should have been completed before it can begin and what can't be done without it. After every piece was put in its right place, the team completed its flowchart. The second part was identifying the responsibilities each party as the customer and the contractor, and also the responsibilities of each member of the team individually.

Documents Analysis. Existing paper manuals were converted to an IETM format by taking the original text and electronic files and tagging them using Standard Generalized Markup Language (SGML). The tagging process was governed by a Document Type Definition (DTD) standard that defines structure for every SGML document instance in the IETM. Second step was converting SGML into HTML format that can be viewed by required browsers. Following steps are implemented by O'Neil & Associates, Inc. to analyze the structure of documents to be converted to SGML:

1. Analyze several documents to determine the type of manual and how the major sections are organized.
2. Analyze the document structure as compared to the DTD.
3. Analyze the anticipated present and future utility of the SGML.
4. Establish a modularization strategy for the data.
5. Determine the enrichment strategy.

There were 20 different type of manuals including operation and maintenance, troubleshooting, service bulletins, service parts, warranty claims, warranty alerts, and field campaigns to be put in the IETM. With 1,500 interim documents, term used by the company for service updates sent to the customer before the new manual is published, total number of pages to be converted was approximately 18,000. Cummins Engine Company was requiring SGML also in the paper manual publishing contracts, so most manuals were authored in SGML, but several older manuals were not available in electronic format. Interim documents were written in Microsoft Word. Cummins Engine Company was using Xyvision in its publishing processes, so there were also a lot of documents in this format. E-mail system of the company was containing similar text-

based files. Overall, approximately 60 percent of total documents was in SGML and 40 percent was in different electronic formats and paper.

One of the biggest problems at that point was to tie together all different types of information. Engine Groups and Engine Serial Numbers (ESN) were the most suitable tying factors since most of the documents had something to do with an engine family. But there were still a lot of data that can be related to the same number and a lot of data that can be left outside. As a solution, some numeric codes called "meta-data" added to documents to provide "hooks" for the search engine to sort information by engine family, build year, application, or fuel system. The smallest pieces of information was coded with a twelve digit number identifying engine family, group code (fuel system, lubrication system, etc.), procedure code (alternators, etc.), built date, and application (remove, install, etc.). Related information would be identified and pulled by query tables created in the database. One area of research was the format of the CD itself based on the ISO 9660 regulations. The ISO 9660 format is a standard for cross-platform CD-ROMs. Discs created in this format can be read by many different operating systems, including Mac, DOS, UNIX, etc. One of the requirement for IETMs was to be operable on Win 3.1 operating system. The ISO 9660 level that supports the discs intended for DOS or Windows 3.x systems requires use of file names to be, at maximum, 8.3 characters length. It has also a limitation of 8 levels of nested directories. The naming convention and directory structure were defined under the considerations of these constraints.

Initially, Intercept was to contain one CD. However, development team decided to have separate CDs for the mid-range engines and the heavy-duty engines to allow for

inclusion of additional manuals in the future. Some of the interim documents were related with more than one engine family so they were included on both CDs.

At that point it may be useful to clarify an issue. SGML is not an obligatory step before converting text files into browser-viewable format. Documents can be converted directly to the HTML (Evans, 1998). But in a long-range project, SGML allows users to view or access their information in different forms (Milligan, 1998). Using open system approach, SGML encode the logical structure of objects below the document level: the various levels of headings, lists, and so forth that people pay attention to when actually reading the information. Furthermore, SGML encodes this information in a neutral format, keeping logical content separate from specific layout decisions, and allowing flexible interchange across different platforms and applications (Severson, 1998). Keeping their database in SGML allowed Cummins Engine Company to publish paper manuals and IETMs at the same time while all the data is coming from one source and provided flexibility in possible future applications.

DTD Selection. The important thing to understand about SGML applications is that they are not all the same. There's actually no such thing as "converting to SGML," only converting to a specific SGML application. SGML is not a set of tags, nor even a specific way of looking at your information, but rather a language for defining the way you want to look at your information (Severson, 1998). "So it is really nothing to SGML. It is what other programs do with it that turns it into something."(Evans, 1998).

SGML applications are based on a specific DTD. SGML DTDs catalog the information objects ("elements") of interest, including their names ("generic identifiers"),

properties (“attributes”), and allowed content (“content models”). Through the content models, the DTD specifies all the allowed relationships between elements, including hierarchical document structure, specific order in which elements must appear, how many each element can appear, what’s required vs. optional, and the possible links between the elements. In some cases current DTD may support another application or require small modifications. Although most of the documents to be converted in Intercept project was in SGML format, current DTD was strictly for paper publishing and did not support required application. A new DTD was developed to allow for database association, expert level summary data, role-based filtering, and security concerns. New DTD was more powerful covering additional features so that the company could do the electronic version and the paper version at the same time. Considerations included converting existing SGML files to the new DTD, converting non-SGML legacy data to the new DTD, and converting all information to HTML for the final product.

Project Planning and Scheduling

After deciding on the format, next step was establishing a master schedule of conversion efforts and monitor the progress against that schedule. In addition to this document, O’Neil & Associates, Inc. prepared a data dictionary to ensure proper implementation of DTD. Control in the process and SGML database was accomplished via a combination of automated tools and process oriented inputs. An important problem at the beginning was that paper publishing and authoring process was continuing at the same time. Twenty authors were writing technical information for the manuals continuously. The team studied procedures to solve this problem and developed a master

schedule plan, which showed the engine families and the number of pages of related information, what kind of procedures they have to take, and scheduled completion dates.

Conversion Process

The initial conversion was accomplished in three phases:

1. Information currently in SGML was converted from the old DTD to the new DTD format using both automated conversion tools and manual labor.
2. Non-SGML information was converted to SGML format using the same procedure but requiring more labor.
3. Graphics files were converted from TIF to GIF files and checked for clarity and accuracy.

When choosing automated conversion tools, differences between software packages are important. Most real-world applications demand use of software based on software recognition rather than standard “code-for-code” translation techniques. The translation approach is generally inadequate because it depends on absolute consistency at a detailed code level. “For example, consider a word-processor document containing section headings that are bold and centered. A typical translation rule would look for a “bold” code followed by a “center” code as the indicator that a heading tag should be generated. In the real world, of course, the “center” code might be entered first. That calls for a second translation rule. But what if the centering was done with tabs, or the space bar, or some combination of both? What if no “bold” code is present because bold had already been turned on from the previous object?” (Severson, 1998). Visual recognition on the other hand looks at the documents the way people do. This technique analyzes the net effect of underlying codes, discovers the visual objects that would “meet

the eye," and assigns them names based on user-defined rules. O'Neil & Associates, Inc. used a combination of manual and software-assisted conversion in Intercept project. OmniMarkTM is used as the automated conversion software.

DTD Conversion. The problem of converting the whole existing database from old DTD to the new one was solved with one-time-conversion. There were separate databases at both parties. Cummins Engine Company was using PDM (Parlance Document Manager) as a database management tool. PDM was a shared, interconnected database and allowed multiple users to use and change the data simultaneously. O'Neil & Associates, Inc.'s database system consisted of VSS (Visual Safe Source) as a repository database and Texcel as the management tool. In order to be able to convert all the database to the new format, developers stopped all the authoring processes, migrated the files from PDM, and stored them in VSS. The authoring process stopped during the migration and did not begin until the conversion was done. Old format converted into new DTD by the programmers, and the files were put back in the database. Once this initial conversion accomplished, there was no further need for conversion in SGML database because the authors would continue writing in the new format.

Hard Copy Conversion. The first step in converting hardcopy to SGML is getting the text into digital form. This can be done by manual rekeying, or automated by OCR scanning. Either way, the result is generally an ASCII file containing text and white space. With hardcopy documents, all structure is visual. There is no underlying encoding to translate to SGML. OCR (Optical Character Recognition) software packages convert scanned image to editable text, suitable into a word processor. OCR identifies

possible errors and highlights them. For example, OCR may not able to distinguish between number "1" and letter "l", or number "0" and letter "O". The operator manually fixes these kinds of errors. Today's OCR packages give more than 99 percent success. But OCR errors can multiply the effect of errors in the conversion process. Thus, it is usually critical to clean up the document before running it further through the process. Still scanning and OCR along with corrections saved great amount of time for O'Neil & Associates, Inc. in hard copy conversion. O'Neil personnel, using an intelligent scanning system, scanned printed pages and stored text and graphics in separate files. The scanner that is used in the process was able to process pages up to 11" x 17" sheet size and scan complex page layouts having multiple text columns with embedded graphics in either portrait landscape mode. The software could process the text from either single or double-sided originals.

During the scanning process, text and graphics are scanned simultaneously and saved as separate files. The scanning system included a conversion module that can convert the text to more than 50 word processing, desktop publishing, and spreadsheet formats; nine raster graphic formats were also available.

Following steps are used to convert hard copy documents to SGML:

1. Evaluate the quality of the text in the hard copy manual.
2. If the document is legible, use an OCR scanner to convert the text to Rich Text Format (RTF) and the drawings to raster graphics.
3. If the document is not legible, use a word processor to type the text into Word format and scan the graphics as raster graphics. Save the text as RTF.

4. Using OmniMark™, develop a filter that will convert the specified RTF format to the new DTD. A separate filter must be developed for each input hardcopy format and for each output DTD. However, many documents can be processed through the same filter as long as the input and output formats are consistent.
5. Using the OmniMark™ filter, convert the digital text in each file to a preliminary tagged document. If the input file format or the DTD output format is different from previous jobs, develop a new filter (step 2).
6. Go to finalization process to populate the database, parse the SGML file, perform the quality checks, and go to HTML conversion (see Figure 9 below).

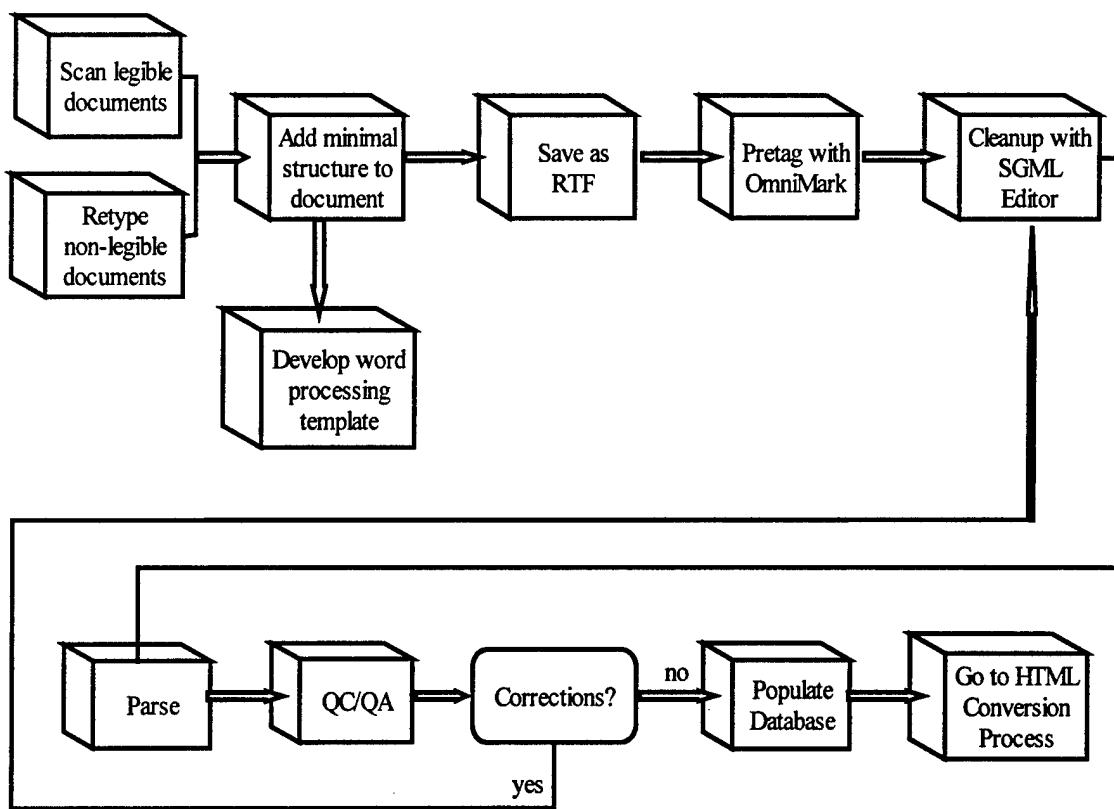


Figure 9. Hard Copy Conversion (Adapted from O'Neil & Associates, 1997d)

Electronic Form Conversion. Conversion to SGML is a lot easier when input has been authored in electronic form. However, there are still things to consider. The input must be in a format the conversion software can automatically read, or it must be easily convertible to a format the software can read. Most electronic documents in that process were authored with only paper presentation in mind, containing no more explicit structure than scanned hardcopy. In the following section, several processes identified which are required to successfully accomplish the conversion effort. The process selected is dependent upon the initial media.

MS Word

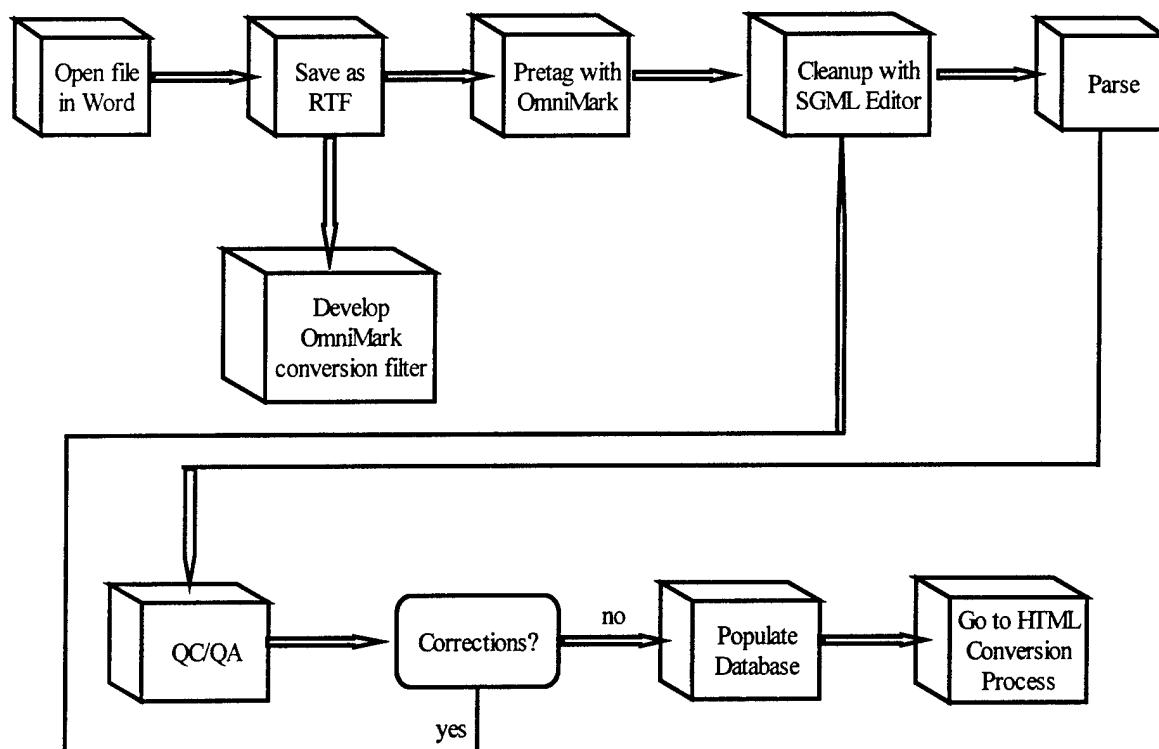


Figure 10. MS Word Conversion (Adapted from O'Neil & Associates, 1997d)

Following steps are used to convert Word (any version) documents to SGML:

1. Use Word to open the file that is to be converted.
2. Save the file in Rich Text Format (RTF).
3. Using OmniMark, develop a filter that will convert the specified Word (RTF) document format to the requisite DTD. A separate filter must be developed for each input Word Format and for each output DTD. However, many documents can be processed through the same filter as long as the input and output formats are consistent.
4. Using the OmniMark filter, convert the RTF codes in each file to a preliminary tagged document. If the input file format or the DTD output format is different from previous jobs, develop a new filter (step 3).
5. Go to SGML finalization process to populate the database, parse the SGML file, perform the quality checks, and go to HTML conversion.

Xyvision (XPP). Similar to MS Word conversion, following steps are followed to convert Xyvision (any version) documents to SGML:

1. Retrieve the Xyvision ASCII file that is to be converted
2. Using OmniMark, develop a filter that will convert the specified Xyvision ASCII document format to the new DTD. Again, a separate filter must be developed for each input Xyvision format and for each output DTD.
3. Using the OmniMark filter, convert the codes in each file to a preliminary tagged document. If the input format or the DTD output format is different from previous jobs, develop a new filter (step 2).

4. Go to SGML finalization process to populate the database, parse the SGML file, perform the quality checks, and go to HTML conversion.

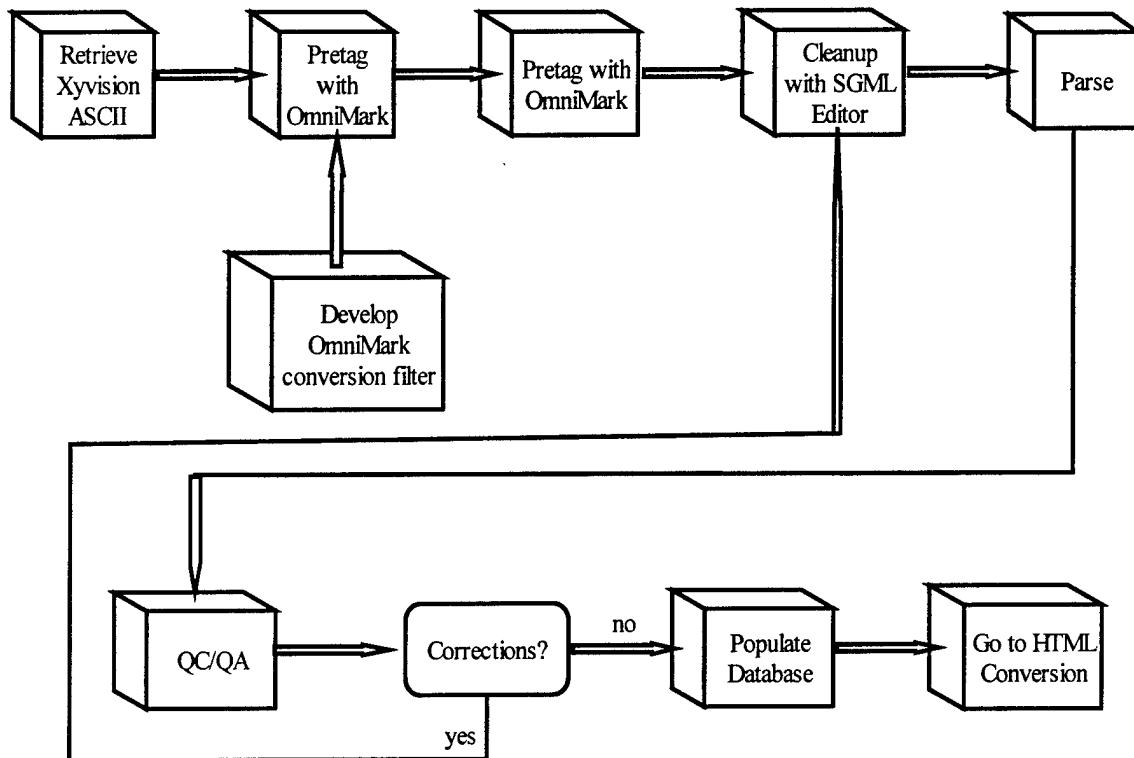


Figure 11. Xyvision Conversion (Adapted from O’Neil & Associates, 1997d)

Graphic Conversion. Illustrations from the legacy shop manuals were existing in hard copy and digital format. Regardless of the graphic format, all drawings must have been converted to an acceptable form that can be viewed by the browsers at desired quality. Legacy digital graphic files in Cummins Engine Company database were in TIFF format. This file format was chosen because of its quality in paper publishing, but was not very appropriate for electronic display, especially because of the space it takes in the memory. TIFF is the acronym for *tagged image file format*, one of the most widely supported file formats for storing bit map images on personal computers (both

PCs and Macintosh computer). TIFF graphics can be any resolution and they can be black and white, gray-scaled, or colorful. The purpose of TIFF is to describe and store raster image data.

The TIFF files were converted to GIF files since CD-ROM was based on Web based technology and Web base can not handle this file type. Amount of space they occupy was another problem. An ordinary TIFF file was containing 3,000 pixels and occupying 700-800 Kilobyte space. A GIF file on the other hand was visible by browsers and occupying approximately 15-20 Kilobyte space and 350-400 pixels. GIF is a bit-mapped graphics file format used by the www and it is one of the most common file formats for the Internet. It has the smallest file size for graphics, and as a result has the fastest download speed. Converting graphics into GIF decreased the resolution of graphics. However, it increased the download speed, and helped to meet the requirement of the graphics' fitting different computer screens with different resolutions. After conversion, GIF files were checked for clarity and accuracy.

Existing files were converted into GIF format and stored in the database. Hard copy graphics were separated from text, scanned, and stored as the same format. There were about 16,000 graphics to be converted in total. Following procedures were followed in graphics conversion:

1. If there are no digital files or the digital files are not acceptable, scan the printed hard-copy pages to create GIF graphic files.
2. Examine each graphic file with a graphic viewer. Compare the image on the viewer screen with the image as it appears on the IETM screen.

3. Using the graphic viewer, examine the header data for each file. Verify that the header data is consistent with the SGML-tagged text and the electronic manual. It is very important to compare each graphic file and its header data against the SGML-tagged text. This will keep graphics from being assigned to the wrong location in the text.
4. Verify that the SGML <graphic> and <sheet> tags refer to the correct graphic file names.

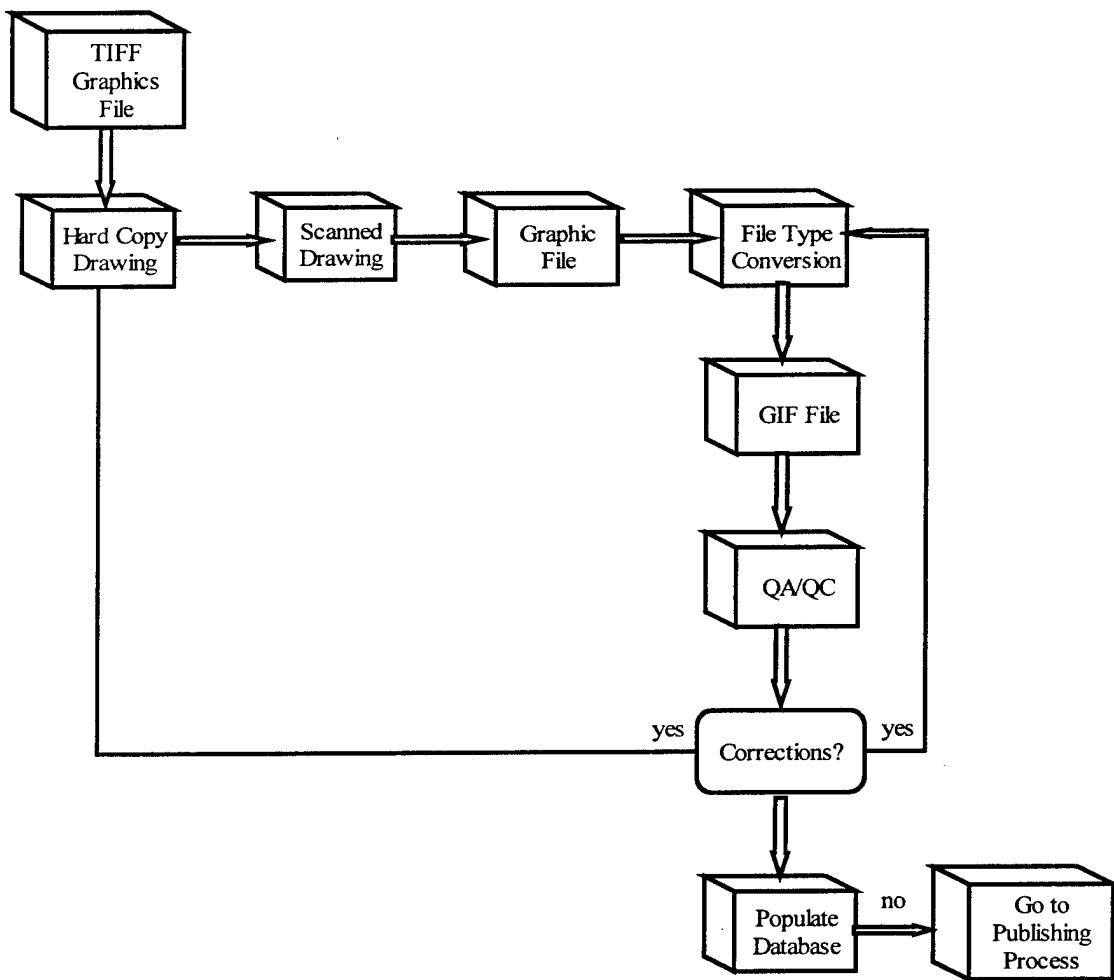


Figure 12. Graphic Conversion (Adapted from O'Neil & Associates, 1997d)

5. Create a declaration file for each graphic. Verify that the data in the declaration files is correct (see also Figure 12 above).

SGML Finalization. Final step in SGML conversion process included SGML Parsing and several quality control procedures. The purpose of the SGML parser is to recognize markup in SGML documents. Together with the entity manager (the software component that makes it possible to segment SGML documents into separate entities), it forms the basis of any conforming SGML system. An SGML parser does not have to be able to detect errors; the only requirement of an SGML parser is the ability to correctly process an error-free SGML document. The parser used in Intercept is called a validating SGML parser and was capable of finding and reporting “reportable markup errors”. It was also capable of optionally reporting other errors and warning of conditions that are potential causes of errors.

Following steps are followed in SGML finalization process:

1. Transfer the tagged files to a document-control database.
2. Use an SGML editor to cleanup the text using one of the following steps in accordance with project requirements:
 - a) Format Edit: link graphics, verify cross-references, insert missing entities, correct syntax errors, adjust table spans, etc.
 - b) Content Edit: reorganize text, reposition graphics, update the technical content, compensate for variations in source material, add content level tags and attributes, etc. That process had to be performed by technical writers who are familiar with the subject matter.

3. Check the tagged document with an SGML parser. If the SGML parser identifies errors, correct the errors accordingly (step1).
4. When the document parses cleanly, check it for spelling errors, SGML logic errors, and text conversion errors. Correct any errors accordingly (step1).
5. Go to HTML conversion process.

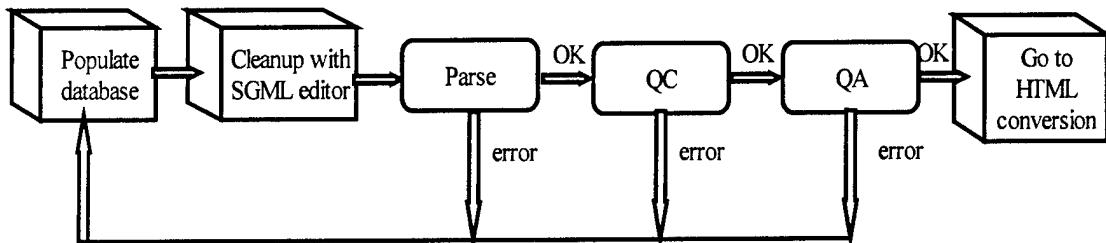


Figure 13. SGML Finalization (Adapted from O’Neil & Associates, 1997d)

Data Enrichment

Besides converting existing data, IETM developers enriched the documents with additional information such as meta-data, summary data, warnings and cautions, and cross references. Meta-data was added to documents to provide “hooks” for the search engine to sort information by engine serial number, family, application, build year, or fuel system. Summary data was added, allowing users to either see procedure highlights and specifications or go to detailed steps. SGML affectivity tags marked information specific to certain manuals since initial information was stored in one database (single-source-authoring). Referenced procedures were hyperlinked, allowing users to quickly access related information contained either in another section of the manual or in a separate manual. Troubleshooting trees were grouped by problem category and linked to Cummins’ electronic Insite Fault Information System by adding fault codes to trees. Summary data was provided by the following processes:

1. Request and receive Engineer's Draft of Summary Data.
2. Review and reauthor Engineer's Draft into Writer's Draft of Summary data.

This involves bringing the information into the proper style and format presentation.

3. Submit Writer's Draft for Engineering/upline review.
4. Make corrections as required.
5. Ongoing documentation and refinement of process.

Total data enrichment task was comprised of the following elements:

1. Add finalized/approved Summary Data information to SGML database.
2. Add ID to Warnings and Cautions.
3. Hotlink cross references as required.
4. Other data enrichment as required.
5. Ongoing documentation and refinement of process.

Database Management

SGML allows the identification of a document (paragraphs, chapters, titles, graphics, etc) as discreet, pre-defined data objects. Since SGML presents information in a highly structure form, data could be stored and maintained in a database. Storing information in database allows documents to be linked (connected in a data structure by using indexed variables or pointers). This enables documents to share common information. Not only does this save writing time and disk space, but also improves the quality and accuracy of the documents and ultimately reduce costs.

After the conversion, all SGML files were stored in a modular database (PDM), which was physically located in Cummins Engine Company information system. SGML

database enabled Cummins Engine to manage information as objects in a common database, share and reuse these objects in multiple documents, and publish the same information in multiple formats. Database management allowed O'Neil & Associates, Inc. to actuate paper publishing and CD-ROM publishing simultaneously, which was one of the most important requirements for the project.

In PDM, lowest maintenance level information was described as modules (data objects). This modular concept is the main idea behind the concept of developing information once and using it many times in different places. Suppose an alternator, which is used in different engines. Instead of authoring the information several times in everywhere needed, the author can write data once, and use it many times by just pointing to that one module.

The naming convention for data modules consisted of five levels for Intercept project. This can be explained by the following example:

035-002-136-020-002

First three digits (first level) gives an information about an engine family, e.g. M11 engine. Second three digits (second level) gives an information about the group member of that engine family. Cummins technical manuals were organized under twenty-two chapters, each chapter for a major component of an engine. Third level gives information about a procedure, e.g. lubricating the oil filter. Fourth level gives information about the step, e.g. install, or remove. The fifth level identifies tasks which differentiate among steps for different situations.

Since project consisted of large amount of documentation, there was redundant information throughout the different documents. For example, some warnings, cautions,

and illustrations had to be duplicated many times throughout a manual. In a conventional publishing system, creating this same information over and over again would be costly and time consuming. When changes were made, the writer had to make sure that each occurrence is properly updated. Repeating the same information at different locations in a document would increase the opportunity for error and likelihood for differences between the various occurrences. With SGML database, each of these common entities appeared just once. The documents required only a pointer (a link) in each place the entity required. Since the entity (warning, caution, drawing, etc.) had only one physical location, it was much easier to maintain.

SGML database gives data management opportunities. When a change is going to be made on existing modules, a database manager assigns that particular change to an author. The author takes a copy of that file and moves it onto his/her desktop. He or she then opens up the file in ADEPT*Editor (an SGML editor) and makes the necessary changes, and then saves it and posts it back into database. During that time, nobody can work on that module and make changes. This application forces having only one version for each document every time. So, anybody who uses modules from the database knows that it is the last versions of the document. The database allows database managers to see which author is working on which module. This makes the planning of activities easier for the database manager. In addition to database managers in Cummins, some managers from O'Neil have access to the database with the rights of a database manager.

As the conversion of graphics follows different but parallel workflow to text conversion, the storage of the graphics is not related to the storage of SGML data. They still reside in same database but not as a part of SGML data. Any kind of graphics can be

used and recognized by SGML. Inside DTD, the engineer tells what kind of graphic files are going to be used in that application. The only thing that limits the use of any graphic files is the kind of medium that SGML application is going to be printed. Overall, SGML data have pointers to graphics. When a graphic file is needed in the presentation of SGML data, the pointer calls for that particular graphics.

Production Process

Production process included converting SGML database into HTML, adding search engine, and writing on the CD's. Same automated conversion tool (OmniMarkTM) was used for HTML conversion. Converting SGML files into HTML format is also called down translation, because it covers all transformations of a "reference" SGML document base into derive formats. The term "down" come from the idea that the SGML document base is designed to model the suitable level of information for the project, and as a result corresponds to the highest level of information. Going from this level of information to any other structure is therefore a down translation. Down translation can be defined and formally specified as a structure-to-structure mapping, because the source of the transformation is a formal (SGML) structure. Thus, HTML conversion process was fairly stable and reliable process.

Installation program and search engine were subcontracted by O'Neil. Developers used InstallShieldTM software for ease of installation and to build in security measures. Users recorded a serial number and password when initially installing the CD, regardless of whether they loaded the program on a local CD drive, local area network, local web server placed on the LAN, or remote web server (intranet).

A search engine was created using Java programming language to link engine serial numbers and configurations to appropriate manuals and interim documents. Combined with a C⁺⁺ database server, the interface launched and controlled the Internet browser, initiated database queries, and constructed and displayed a dynamic table of contents listing all pertinent documents. Specifying an ESN allowed the user to see information specific to that engine, including where and when the engine was built. Because Windows 3.1 did not support Java, HTML menus were included with hyperlinks for navigation; however, no ESN searches could be conducted.

Quality Assurance

Both Cummins and O'Neil participated in quality control and testing. After developing a comprehensive test plan, the teams used automated and manual methods. Quality assurance started with checking the electronic files for consistency and completeness. These files were compared to the hard-copy documents that they were identical. During file transfers it was possible that data may be added, lost, or transferred incorrectly. Catching problems early during the project helped the project team to avoid the problems in production process. After each document was converted into SGML, tagged data was compared to original documents. That was a two-fold process. First, the documents were compared to ensure that no data was lost during the conversion procedure. Second, the tags were checked for accuracy. An SGML parser was used to check the tagging completeness, however a parser could not catch everything. Team members found that combining manual proof-reading with electronic checking using multiple parsers gave the best results to ensure the quality of process. The functionality and contents of the CDs were verified. In addition, Cummins arranged applications for

field testing and receiving of customers' feedback. The software tested on various hardware configurations, using Windows 3.1, Windows 95, and Windows NT operating systems and both browsers.

Final Product

The first CD for the heavy-duty engines was released in November 1997, and the mid-range CD was released in March 1998. The CD set contains more than 20 manuals, 1,500 interim documents, 18,000 pages of technical information, and 16,000 illustrations as well as Customer Assistance Center Frequently Asked Questions and Cummins Engine Company's Insite Fault Information System. Using a search routine based on ESN, engine type, or fuel system, an engine specific Table of Contents is created on-the-fly to allow access to information tailored to the user in a "role based view" (Field Technician, Warranty Administrator, etc.). When accessing the repair and maintenance procedures, the user can scroll through a detailed task description complete with support illustrations; or in the case of a more experienced user, can complete the task by means of summarized version of the procedure. Procedural data and troubleshooting are interactively linked to other manuals, and to the Fault Information System for online trouble shooting and diagnostic support. Users subscribed to the service and received updates every two months. According to Cummins Engine Company customer feedback, Intercept covered a large percentage of data frequently used by a broad range of target users. Future plans of the company includes adding hyperlinks to service tool instructions, an on-line parts list manual application, warranty coverages by engine serial numbers, and new manuals. Longer-term upgrades may include additional markets and

information types, integration with other products and systems, full text search capability, updated interim documents via internet and e-mail, and forums/chat services.

V. Conclusions, Recommendations, and Suggestions for Future Research

Introduction

This chapter will summarize the research effort and offer conclusions to the research based on the findings presented in Chapter IV. It includes a lessons learned part which summarizes what was learned about IETM development process at the end of this case. Recommendations concerning future Air Force training and suggestions for future research will also be presented.

Lessons Learned

In any IETM development, the “starting point” and “ending point” are critical factors for determining the nature of the project. By “starting point”, we mean the technical information itself, and its format. Technical information may be in variety of formats such as on paper, in electronic form, or in SGML. The accuracy of technical information, and consistency of its structure are the determinants of the difficulty of conversion. Suppose, there are two types of document in electronic format such as a word document. Suppose, furthermore, one of them has very consistent structure, whereas the other has a loose structure. An automated conversion can be validated for the technical information with consistent structure, whereas a loose structured document may have to be reauthored in SGML.

By “ending point”, we mean interactivity, hardware, and software requirements. Interactivity requirements determine how an IETM will interact with users. IETMs may require simply linear representation of technical information when interactivity is

minimum. On the other hand, they may help the technician with the task he or she is doing where interactivity is high, such as fault identification, or trouble shooting with the help of artificial intelligence. The main difference between a paper manual and an IETM is that IETMs are enriched by hypertext and hypermedia. You can enrich technical data in a variety of ways such as by adding pop-up menus, audio files, and video files. You can add data base hooks to other related information such as other databases, and complementary information (warranty, and service information etc.). Hypertext and hypermedia information which may be explicit or implicit in technical data must be captured in document analysis.

Hardware and software requirements also have important implications on how IETMs are developed. Naming convention in Intercept had be restricted 8.3 length according to ISO 9660 standard since it was requirement that IETMs would be operable on Win 3.1 operating system. Remember, new versions of two browsers, namely, Internet Explorer, and Netscape Navigator did not allow the use of developed Intercept IETMs. However, users did not have problems since old versions were supplied in Intercept CDs. Another considerations in Intercept were fitting all graphics into variety of screens with different resolutions. That challenge was handled by modifying graphics by percentages in GIF format. These are examples from Intercept project that point out the importance of hardware, and software implications on an IETM development project.

In above discussion, it emphasizes the important implications of “starting point” and “ending point” by examples in any IETM development project. Preplanning is the stage where all these issues as well as other related issues are solved. Early decisions made in the project determine the success of an IETM development project. They are

vital since it may prove to be costly to alter them in later stages. Activities in preplanning can be grouped under several categories as we did in Chapter IV. “Proof of concept” is the stage where IETM development project is shown to be possible and affordable. “Identification of system requirements” is the stage where output specifications and functionality requirements (these are called and “ending point” above in this discussion) are identified in the areas of interactivity, hardware, and software requirements.

“Document analysis” is the stage where input documents are analyzed (identification of “starting point”). The most important output of preplanning process is the mapping of IETM development activities from “starting point” to the ending point. It requires identification of responsibilities of the IETM developer company and its customer in project level; responsibilities of each person in development level; consistent flowchart for activities; and selection of right hardware and software tools. It is important to require the participation of people from each profession such as authoring, programming, and manufacturing since acquiring inputs from different disciplines helps to early identifications of inefficiencies in planning.

After the discussion of importance of preplanning activities in addition to implications of “starting point” and “ending point” for the success of an IETM development project, the conversion process itself is going to be discussed now. The common thing about all input documents is that they are all converted into SGML format. This is called “up translation”, as discussed in Chapter II. “Up” follows from the fact that SGML is highest level of markup languages that all other languages can be defined from it.

Before going further with the discussion of conversion issues, we want to point out SGML is not the only IETM solution. For example, Portable Document File (PDF) is another format that is encountered in IETM projects. As discussed in chapter 2, PDF is a de facto standard in IETM industry. For example, U.S. Air Force has chosen to convert the 16 million page legacy data (existing TOs) to Indexed Portable Document Format in April 1995. Almost half of the customers of O'Neil has been demanding their IETMs in PDF format, SGML is increasingly gaining popularity among its customers at the time of this thesis. We think the main consideration behind these facts is the conversion cost of legacy data. As one of O'Neil & Associates personnel points out, you can get cost savings as much as one to ten by selecting PDF rather than SGML as your IETM format. You can mix PDF applications with SGML. However, the major drawback with PDF is that it is not easy to make changes in PDF applications. For example, you can change or add one sentence, but you can not add one paragraph to a page. You have to redo IETM development for considerable changes with PDF.

It is possible to categorize input documents for “up-translation” into three categories: 1) hardcopy, which is thought to be the hardest starting point of all three, 2) electronic documents, which comprise of large variety of documents other than hardcopy, and 3) SGML, which is thought to be the easiest starting point among all three. It is important to point out that electronic formats are elusive. The conversion of them may be as hard as hardcopy in situations where structure of documents is considerably inconsistent, and/or accuracy of technical information is low. On the other hand, when the structure is very consistent such as with most technical documents developed in markup languages, you may expect successful automated conversion. However, in most

of electronic conversion projects, human review is still required for quality control purposes. Hardcopy conversion requires scanning activity to convert technical information to electronic format, then to SGML. Scanning is, further, going to be discussed later in this chapter.

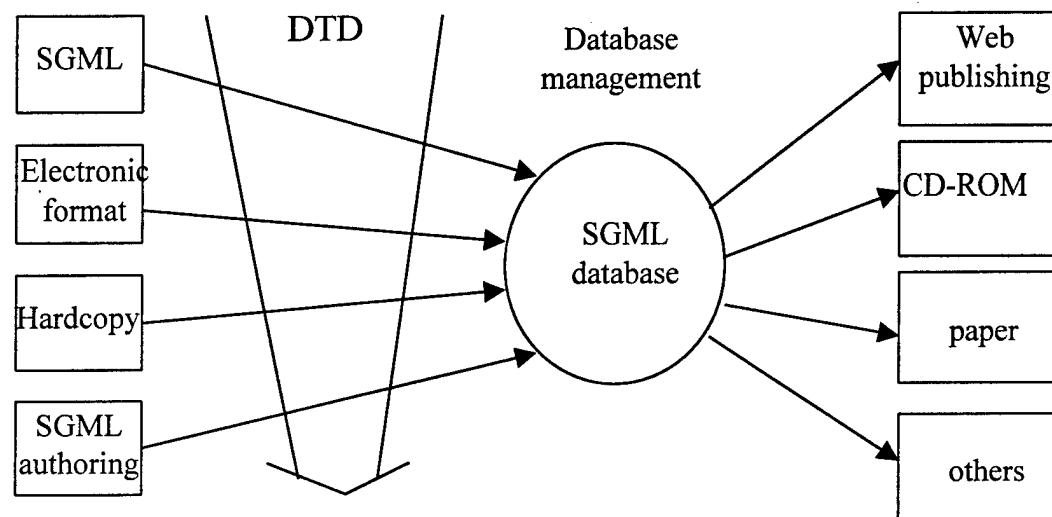
As discussed in Chapter II, “down-translation” is the conversion from SGML to other formats such as to HTML format for Web publishing. Another approach is SGML-aware software. For example, Magliery says one alternative to converting SGML to HTML is developing SGML-aware software that can browse the Web, either by itself or with help of another browser (Magliery, 1998). There are some companies such as Softquad-the Panorama viewer, and Hal-the OLIAS browser, which are developing this approach. However, it seems that this approach has not been proven to be cost-effective for end users in the field yet, as of today. Overall, SGML can be published on Web, on a CD, on paper, or other formats. “Down-translation” is generally easier than “up-translation” since information is at the highest level in SGML format.

Last two topics that are going to be discussed under this section are Quality Control/Quality Assurance and SGML database management. The quality assurance program and the quality control itself are the insurance that all, but right technical information is captured, and tagging is complete and consistent. A good planning at early stages is key to success. Some of activities can be automated such as using parsers to check the tagged instance conforms the rules defined by respective DTD. However the importance of human review in the process is vital for success. The best way to approach quality control activities is to use automated tools and human review together, as complement to each other.

As discussed earlier, SGML is just ASCII text. What makes SGML applications so attractive is what other tools do with it. A database is one of these tools. An SGML database allows the management of technical data as data objects (modules). A data object is the smallest bit of information that resides in database, but how big the size of these objects requires a decision by the IETM developer. For example, in the Intercept project an install or a replace procedure (called step by project team as discussed in Chapter IV) was a data object.

The importance of the size of a module is best explained by an example. Suppose, a maintenance procedure such as an install or replace procedure with a part number within the text of this procedure. You may call the maintenance procedure as the smallest data object, by leaving the part number as it is in the text. Another scenario for this example may be identification of the part number also as a data object. This very same number may be a part, say, of 100 maintenance procedures. Defining the part number as data object gives the chance of making an update about the part number once, and using it many at different places. Because the part number exists in database in one place, and all maintenance procedure that have this part number as part of their text point to it. This approach gives better management of data since you make capture a data once, use it many places. However, the cost is another consideration in making a decision about how much modularity you want. This decision should follow from the realities of a given project. Do the benefits of high level of modularity outweigh the costs entailed? Above, important factors that have implications on an IETM development application are discussed. Now, IETM development activities are going to be visualized as a process in Figure 14. As can be noticed from the Figure 14, an IETM development process may

exactly look like the process of electronic publishing in different sectors of industry. The reason for this is that IETM concept is a result of technological improvements in computer technology, not vice versa. However, SGML is not restricted to IETM concept.



Preplanning	Conversion	Information Management	Deployment
<ul style="list-style-type: none"> • Proof of concept • Identification of system req. • Document analysis • Identification of responsibilities • Tool selection 	<ul style="list-style-type: none"> • Conversion or direct SGML authoring • Enrichment of technical data • Quality control 	<ul style="list-style-type: none"> • Database management 	<ul style="list-style-type: none"> • Translation to other formats

Figure 14. IETM Development Activities

Figure 14 emphasizes IETM development as a process. However, one important consideration in IETM development is support and maintenance of IETMs. This may require upgrading of software and hardware requirements; updating the content of IETMs itself. One other point that should be emphasized is that quality control seems a part of

conversion step in Figure 14. The reason is to emphasize quality control activities including both automated and manual in that step. However, quality control and quality assurance (QC\QA) program comprises all IETM development steps. It requires contribution of both developer and customer, and starts as early as in preplanning step.

Conclusions

Driving Factors of Private Sector

Our case study showed that prioritization of driving forces in private sector is different from the military environment. Let's look at what DoD expects as benefits from IETM implementation (Pechersky, 1989:67):

- increase in productivity by automating authoring process.
- improvement in trouble-shooting accuracy.
- Savings in technical manual reproduction, acquisition, and system life-cycle costs.

As can be seen, most of the driving factors that DoD takes into consideration are related with technical and operational improvement. In the above list taken from a report prepared for DoD, cost factor comes third, and customer response is not even mentioned. This is usually the order met in any DoD source. In private sector, on the other hand, we saw that there are two main drivers:

1. Customer response: Unless the company also manipulates maintenance actions of its products or a leader in the industry, developing an IETM is strictly dependent upon whether its customers want it or not.

2. Cost: If the overall cost along with cost of missed sales because of lack of electronic manuals (if any) is more than cost of current applications, it is highly difficult for a firm in the private sector to justify the change to IETMs.

Only after these factors are met, are the other benefits discussed above considered.

Importance of Coordination and Using Standards

An IETM development requires the collaboration of many people from different disciplines such as authoring, programming, and manufacturing. It is also vital that both customer and developer have the same understanding of final product. In Intercept project, O'Neil was the only IETM developer company; however, there may be situation in which an IETM development is a group effort among several IETM developers. In this case coordination of activities is more vital for the success of the project. The main contractor bears most of the coordination responsibility. (Rest of this discussion mostly relates a new development from scratch, not a conversion). First of all, the main contractor should specify a DTD. It is also important that it specify a naming convention for common technical terms so that everybody can use same names when referring to same tool, or same procedure etc. Another issue is the use of the same orthographic (flat) graphics by every contractor. The main contractor should come up with orthographic graphics for common items such as screws, bolts, etc. and distribute them to subcontractors. This will allow consistent graphic representation of common items in different graphics. For example, a screw may be used ,say, fifteen subcomponents of an engine. Not having a standard representation format would cause different representation of the same screw as a part of these subcomponents. In international projects, one issue to above discussion should be added the use of simplified English.

Dash 8 is a major aircraft program O'Neil & Associates is part of. There are fifteen major partners that are responsible for different aircraft systems (fuel, hydraulics, power plant, etc.). These partners are located all around the world. All partners are responsible for their chapters of the Aircraft Maintenance Manual (AMM) and Illustrated Parts Catalog (IPC). To maintain the consistency throughout the manuals, the Airframe Manufacturer has developed extensive and detailed specifications for SGML, writing, and illustrations. Uniformity is also accomplished through use of AECMA (The European Association of Aerospace Industries) Simplified English. (O'Neil & Associates, 1996e).

AECMA Simplified English has been developed by the aerospace industry and its customers to help the preparation of maintenance manuals that are both clear and unambiguous for English speakers and non-native English speakers alike (The European Association of Aerospace Industries Web Page, 1998). The specification provides a set of writing rules and a dictionary of agreed words with their meanings.

Above example illustrates the importance of the use of standards when the project requires several IETM developers either in national level or international level. Another reason for using standards can be tied to technological changes in processing digital data. Rapid change in technology requires changes in companies' service and maintenance strategy, input and output devices, input and output formats, and technical requirements and capabilities. In order to be able to use technical data that has been produced before, new systems can be capable of handling legacy data or data that has been produced in different platforms. Only in that case can major objective of digitization efforts "creating data once", and "using it many times in many places" be achieved.

Role of the DoD in Establishing Standards

During the case study, the researchers noted that when there is a lack of standards in industry, DoD standards are either directly used or referenced by industry. U.S. military has been the leading player in IETM standards because of its position and its relative size. Although there are some standardization efforts in terms of development of a common DTDs for specific sectors such as ATA 100, ATA 21000, and ASE J2008 specifications, these efforts are not as big as those undertaken by DoD. Being the largest customer makes DoD a leader in establishing standards for digital data applications.

That is also appropriate for the industry because of two reasons:

1. Industry itself is in search of global standards.
2. U.S. military is the largest contracting agent in the world. Most of the firms in private sector are doing work with DoD in some phase of their company lives and have to comply with these standards.

Identifying a third reason as “DoD has managed to establish well built standards” is out of scope of this study. But it is a reality that these standards are not sufficient in today’s environment. Writers of this thesis do not expect the role of DoD in establishing standards in digitization to increase in the near future because of the other more powerful trends in defense environment, which force the military to buy whatever is available in the market as much as possible, and in some cases avoid highly detailed standard definitions.

Role of Conversion in IETM Development

Another finding of the study was that conversion process occupies an important place in today’s IETM development efforts. This is primarily because legacy data exists

in different forms. Lack of standards in either creating digital files or developing IETMs makes any type of conversion obligatory at some place. As discussed in chapter 2, product documentation is traditionally considered as the last step in a production process in the life cycle of a product. Unless the technical data that is created in the earlier phases of the life cycle of a product does support the product documentation, problem of converting from one type to another is likely to continue. For example, the graphics developed in the research and development with CAD\CAM tools can be directly used in the production of technical documentation. However, this was not the case in new IETM development efforts in O'Neil since most of its customer could not supply original engineering drawings developed with CAD\CAM tools. This caused the duplication of efforts in IETM development process. The engineers who develop engineering drawings were hopeful that they were able get CAD\CAM drawings from their customers in the future, thus they would not have to redevelop them later.

Future Considerations

In a rapid changing environment in which you don't know what the future will require, the things to consider before beginning an IETM development project are limitless. Some factors to consider in addition to technical and operational aspects discussed in this study may be adjusting the product according to the developments or changes in technology, or setting standards at a very high level that will allow the product to be compatible with the future technologies. Although this is a difficult task, it is not impossible since new applications are not completely disregarding the old technologies. It is debatable that these factors must be thought by the customers and identified in the

agreement, or it is data producer companies' task. But planning about future gets more important in an IETM development.

Which Class of IETM?

In intercept project, the system requirements did not require the restructuring of technical data, thus IETMs in Intercept could be thought as class 3 IETM in terms of DoD classifications. However, technical data is managed as data object (modules) in an SGML database. And this is the one of the requirements for class 4 in DoD. So, is it better to call IETMs in Intercept project class 3 or class 4 according to DoD classifications? What is important is that an IETM should reflect the needs of user. It is important to start with users' need, and prioritizing them. And, your requirements should be finalized as a result of cost-benefit analysis during preplanning stage. However, it is not right to sacrifice some of important systems requirements due to cost considerations. Converting your technical documents to SGML would not guarantee adding new features in a cost-effective way in the future. For example, converting your legacy data into class 3 IETM, and requesting to promote it class 4 in future may prove to be costly since technical information has to be restructured hierarchically.

Recommendations for Future Research

In this thesis, an IETM development project, namely, Intercept, in industry setting is investigated. Important factors that have implications on IETMs and IETM development steps themselves are explained. As one can see (See Figure 14), an IETM development as a process is not very different from an electronic publishing project in

industry. It becomes clear IETM development process will be affected by changes in technology and standards, not vice versa.

As discussed in Chapter II, today's IETM development is not without problems. One of the problem is that standards can not keep pace with technology. IETMs deployed today use various types of graphic formats and styles. As discussed in Chapter II, most IETMs uses proprietary styles since SGML does not support styles as opposed to content, and structure. This case study is a typical example of the ineffectiveness of graphics standards. Deployed IETMs in Intercept project were in GIF format to support Web browsers. None of CALS graphic standards support Web based publishing which is becoming very popular for Internet as well as CD-ROM publishing. A follow-on study could focus on possible solutions to ineffectiveness of IETM standards. Particularly, what type of solutions can be expected from the development of STEP standards which aim to combine product documentation into the total life cycle of manufactured products.

Another problem area in today's IETM development environment is interoperability. It is more emphasized in military than industry. Jorgensen identifies the problem as follows:

As the use of IETMs became more widespread, it became important to establish an infrastructure to manage and distribute IETM updates to multiple field sites and to provide life-cycle support for numerous IETMs. In this environment, the fact that differing IETMs cannot interoperate (i.e., cannot be viewed on the same standard presentation system, or electronically reference each other to any meaningful level of internal granularity) has become a major impediment. (Jorgensen, 1996)

There are several projects in DoD to provide solutions to interoperability problems with IETMs. The interoperability problem and possible solutions provided by Interoperability projects in DoD can be an area of a research.

There are some articles in literature which discuss the possibility of getting rid of technical manuals. As discussed in Chapter 1, technical documentation for technologically advanced system is increasing exponentially. Technical procedures as maintenance and operation of are getting more and more complex. Including technical information within product is one of the approaches discussed in literature. A follow-on research may investigate the possibility of getting rid of technical manuals in the future.

Summary

This thesis investigated how a specific IETM development application is accomplished in a civilian environment. First, benefits of IETMs and problems with paper manuals were discussed. Then, IETM development steps were identified. These steps were preplanning, conversion, database management, and deployment. The specific case example involves conversion of legacy data. The form of this legacy data necessitated conversion to SGML (known as "up-translation"), while the requirement for usability with commercially available browsers also entailed "down-translation" to HTML. Lessons learned from the case study were also discussed. Among them was the understanding of different driving factors which motivated organizations in industry than those in DoD. The customer response and cost were main considerations for industry in an IETM development project, while operational and technical improvements such as enhanced trouble shooting and reduced maintenance time were emphasized in DoD. Overall this thesis was important in two aspects:

- It identified IETM development steps, about which there was little research effort in the literature.

- It investigated a specific case in a civilian environment. There was a little research about what civilian industry was doing about IETMs, especially in the area of how IETMs are developed.

Appendix A. Glossary of Terms

ASCII (American Standard Code for Information Interchange). The basis of character sets used in almost all present-day computers. This is the de facto worldwide standard for the code numbers used by computers to represent all the upper and lower-case Latin letters, numbers, punctuation, etc. There are 128 standard ASCII codes, each of which can be represented by a 7 digit binary number: 0000000 through 1111111.

ATA 100. ATA (Air Transport Association) standard that specifies document type definition to be used in by the airlines and related manufacturers at development of technical manuals.

ATA 2100. ATA (Air Transport Association) standard that establishes recommended standards for the presentation of technical information prepared as digital media (magnetic tape or CD-ROM) produced by aviation manufacturers and used by airlines and other segments of the industry in the maintenance of their respective products (Air Transport Association –Publications).

Automated Conversion Tools. Software based translation techniques used to translate one type of file format into another.

Bitmap. A data file or structure which corresponds bit for bit with an image displayed on a screen, probably in the same format as it would be stored in the display's video memory or maybe as a device independent bitmap. A bitmap is characterized by the width and height of the image in pixels and the number of bits per pixel which determines the number of shades of gray or colors it can represent.

BLOB. Binary Large Objects.

Browser. A client program (software) that is used to look at various kinds of Internet resources.

CAD\CAM. Computer Aided Design \ Computer Aided Manufacturing.

CALS. Continuous Acquisition Life-cycle Support. A DoD and industry strategy to enable the integration of digital technical information, including technical manuals (TOS), for system / equipment acquisition, design, manufacture, and support.

CCITT Group 4 (International Consultative Committee on Telegraphy and Telephony).

CALS standard for raster graphics incorporating tiling, which divides a large image into tiles. You can exchange graphic files in CCITT/4 format in a compressed state so they take up much less file space.

CD-ROM. Compact disk-read only memory

CGM (Computer Graphics Metafile). One of the CALS standard formats for representing 2-D technical illustrations. CGM is an object-oriented graphic format.

Client. A computer system or process that requests a service of another computer system or process (a "server") using some kind of protocol and accepts the server's responses.

Cross-Translation. Occurs when there is an SGML document that uses DTD "A" and now DTD "B" is the preferred form.

Database Management System. A suite of programs which typically manage large structured sets of persistent data, offering ad hoc query facilities to many users.

Descriptive Markup (also known as “generic markup”). Describes the purpose of the text in a document rather than its physical appearance on the page.

Document Instance. SGML tagged document. It is also called tagged instance.

Document Type. SGML introduces the notion of a document type. Documents are regarded as having types, just as other objects processed by computers do.

Down-Translation. Conversation from SGML to other formats. A typical example of “down-translation” is the conversion of data from SGML format into HTML format.

DTD (Document Type Definition). Formal definition of the elements, structures, and rules for marking up a given type of SGML document.

DSSSL (Document Style Semantics and Specification Language). An international standard that applies to the specification of processing information for SGML documents.

Encoding. Converting data or some physical quantity into a given format.

Ethernet. A very common method of networking computers in a LAN. Ethernet will handle about 10,000,000 bits-per-second and can be used with almost any kind of computer.

FOSI (Formatting Output Specification Instance). A DTD standard used for formatting SGML documents for printing and other outputs. It is a separate file that contains formatting information for each element in a document.

GIF (Graphic Interchange Format). A common format for image files, especially suitable for images containing large areas of the same color. GIF format files of simple images

are often smaller than the same file would be if stored in JPEG format, but GIF format does not store photographic images as well as JPEG.

HTML (Hypertext Markup Language). The coding language used to create Hypertext documents for use on the World Wide Web. HTML looks a lot like old-fashioned typesetting code, where you surround a block of text with codes that indicate how it should appear. Additionally, in HTML you can specify that a block of text, or a word, is linked to another file on the Internet. HTML files are meant to be viewed using a World Wide Web Client Program, such as Netscape or Mosaic.

Hypermedia. All kinds of sound and video attachments incorporated into electronic documents, which will be accessible via hyperlinks.

Hypertext. Any text that contains links to other documents - words or phrases in the document that can be chosen by a reader and which cause another document to be retrieved and displayed. A link doesn't just have to be text, however -- pictures and icons can also be "clickable."

IETM (Interactive Electronic Technical Manuals). A package of information required for the diagnosis and maintenance of a weapon systems, optimally arranged and formatted for interactive screen presentation to the end-user.

IGES (Initial Graphics Exchange Specification). Standard for exchanging 3-D vector, CAD type data; primarily used for translating engineering drawings into digital form.

Internet (Upper case I). The vast collection of inter-connected networks that all use the TCP/IP protocols and that evolved from the ARPANET of the late 60's and early 70's.

The Internet now (July 1995) connects roughly 60,000 independent networks into a vast global internet.

internet (Lower case i). Any time you connect two or more networks together, you have an internet - as in inter-national or inter-state.

Intranet. A private network inside a company or organization that uses the same kinds of software that you would find on the public Internet, but that is only for internal use.

ISO (International Organization for Standardization). An industry-supported organization that establishes worldwide standards for everything from data interchange formats to film speed specifications.

JAVA. A simple, object-oriented, distributed, interpreted, robust, secure, architecture-neutral, portable, dynamic, general-purpose programming language developed by Sun Microsystems in 1995. Java supports programming for the Internet in the form of platform-independent Java "applets".

Knowledge Acquisition. Process of eliciting knowledge from experts in field to support decision support systems.

LAN (Local Area Network). A computer network limited to the immediate area, usually the same building or floor of a building.

Lexical Analysis. The first stage of processing a language. The stream of characters making up the source program or other input is read one at a time and grouped into lexemes (or "tokens") - word-like pieces such as keywords, identifiers, literals and punctuation. The lexemes are then passed to the parser.

Lexical Analyzer. The initial input stage of a language processor (e.g. a compiler), the part that performs lexical analysis.

Markup. In computerised document preparation, a method of adding information to the text indicating the logical components of a document, or instructions for layout of the text on the page or other information which can be interpreted by some automatic system.

Meta-data. Data about data. In data processing, meta-data is definitional data that provides information about or documentation of other data managed within an application or environment. For example, meta data would document data about data elements or attributes, (name, size, data type, etc) and data about records or data structures (length, fields, columns, etc) and data about data (where it is located, how it is associated, ownership, etc.). Meta data may include descriptive information about the context, quality and condition, or characteristics of the data.

Network. Hardware and software data communication systems. Any time you connect two or more computers together so that they can share resources, you have a computer network. Connect two or more networks together and you have an internet.

MIL-HDBK-2800. An SMGL implementation guide used by U.S. military.

MIL-PRF-87268. A military IETM specification that defines how the IETM should look and behave to the reader.

MIL-PRF-87269. A military IETM specification that establishes the IETM database forms, structure, and key controlling mechanisms.

MIL-Q-87270. A military IETM specification that prescribes the requirements for an IETM Contractor's Quality Assurance (QA) program.

Object Oriented Programming. Writing programs in one of a class of programming languages and techniques based on the concept of an "object" which is a data structure encapsulated with a set of routines, called "methods" which operate on the data.

Operations on the data can only be performed via these methods, which are common to all objects which are instances of a particular "class".

OCR (Optical Character Recognition). Process of turning an image into computer-edible format. Recognition of printed or written characters by computer.

OmniMark™. Automated conversion tool that is used in Intercept project for both digital format-to-SGML and SGML-to-HTML conversion.

OS (Output Specification). Standards-based style sheets developed by DoD. It is in the form of a particular DTD that allows the user to create a Formatting Output Specification Instance, or FOSI.

PDF (Portable Document Format). The native file format for Adobe Systems' Acrobat. PDF is the file format for representing documents in a manner that is independent of the original application software, hardware, and operating system used to create those documents. A PDF file can describe documents containing any combination of text, graphics, and images in a device-independent and resolution independent format. These documents can be one page or thousands of pages, very simple or extremely complex with a rich use of fonts, graphics, colour and images.

PDM (Parlance Document Manager). A compound document management system that enables users to manage information as objects in a common database, share and reuse these objects in multiple documents, and publish the same information in multiple

formats. In this case it is used by Cummins Engine Company as a database management tool.

Pixel. Picture element. The smallest resolvable rectangular area of an image, either on a screen or stored in memory. Each pixel in a monochrome image has its own brightness, from 0 for black to the maximum value (e.g. 255 for an eight-bit pixel) for white. In a color image, each pixel has its own brightness and color, usually represented as a triple of red, green and blue intensities.

Procedural Markup. Defines what processing is to be carried out at particular points in a document.

Product Data. Carries essential information about the design, manufacture, operations, etc. of the actual production of an enterprise.

Product Documentation. Describes many aspects of a product; its design, use, maintenance, disposal, etc.

Proof Concept. Making it sure that the data conversion for legacy information is both possible and affordable.

RAM (Random Access Memory). A data storage device for which the order of access to different locations does not affect the speed of access.

RTF. Rich Text Format. An interchange format for exchange of documents between different document preparation systems.

QC\QA. Quality Control \ Quality Assurance.

Operating System. The low-level software which schedules tasks, allocates storage, handles the interface to peripheral hardware and presents a default interface to the user when no application program is running.

Raster Images. Computer graphics in which an image is composed of an array of pixels arranged in rows and columns. They are presented as matrix, or grid, or tiny black and white dots.

SAE J2008 (Society of Automotive Engineers). A family of standards developed by the membership of the Society of Automotive Engineers to provide easy access to emission-related automotive service information.

Search Engine. A remotely accessible program that lets you do keyword searches for information on the Internet or other browsable documents. There are several types of search engines; the search may cover titles of documents, URLs, headers, or the full text.

SGML (Standard Generalized Markup Language). An international standard (ISO 8879), published in 1986, for the definition of device-independent, system-independent methods of representing texts in electronic form.

SGML Parser. An algorithm or program to determine the syntactic structure of a sentence or string of symbols in some language, in this case SGML. A parser normally takes as input a sequence of tokens output by a lexical analyser. It may produce some kind of abstract syntax tree as output.

SQL (Structured Query Language). De facto access language for relational databases.

STEP (The Standard for Exchange of Product Model Data). ISO standard (ISO 10303) whose goal is to enable a product representation to be exchanged without any loss of completeness.

Tag. A formatting command included an HTML (or other) document. In the world of SGML, a tag is marker embedded in a document that indicates the purpose or function of the element. Each element has a beginning and ending tag.

Tagged Instance. SGML tagged document. It is also called document instance.

TCP/IP (Transmission Control Protocol/Internet Protocol). This is the suite of protocols that defines the Internet. Originally designed for the UNIX operating system, TCP/IP software is now available for every major kind of computer operating system. To be truly on the Internet, your computer must have TCP/IP software.

TeX. A typesetting system that it is intended for the creation of beautiful books-and especially for books that contain a lot of mathematics.

TIFF (Tagged Image File Format). A file format used for still-image bitmaps, stored in tagged fields. Application programs can use the tags to accept or ignore fields, depending on their capabilities. While TIFF was designed to be extensible, it lacked a core of useful functionality, so that most useful functions (e.g. lossless 24-bit color) requires nonstandard, often redundant, extensions. The incompatibility of extensions has led some to expand "TIFF" as "Thousands of Incompatible File Formats".

TO. Technical Order

Token. A basic, grammatically indivisible unit of a language such as a keyword, operator or identifier.

Unix. An interactive time-sharing operating system invented in 1969 by Ken Thompson.

Up-translation. Conversion from other formats to SGML. Since SGML is thought to be highest level information, this conversion process is called "up-translation".

Vector Images. A drawing program which deals with separate shapes such as lines, polygons, and text and groups of such objects as opposed to a painting program which stores only bitmaps. The advantage is that it is possible to change any element of the picture at any time since each part is stored as an independent object whereas once something in a bitmap has been overwritten it cannot in general be retrieved.

WWW (World Wide Web). Frequently used (incorrectly) when referring to "The Internet", WWW has two major meanings - First, loosely used: the whole constellation of resources that can be accessed using Gopher, FTP, HTTP, telnet, USENET, WAIS and some other tools. Second, the universe of hypertext servers (HTTP servers) which are the servers that allow text, graphics, sound files, etc. to be mixed together.

XML (Extensible Markup Language). A new standard defining an "extremely simple" dialect of SGML suitable for use on the World-Wide Web.

XPP (Xyvision Production Publisher). An industrial composition and pagination system that automates the production of complex documents.
of contents. Select "View--Field Codes" to display/hide field codes. Chapter number is between the quotes in the field code.

Appendix B. Military and Industry Technical Manuals Delivery Specifications

DOD	INDUSTRY	APPLICATIONS
MIL-HDBK-59		Provide guidance on the technology, standards, and procurement process as related to the translation from a paper intensive activity to one operating with digital information
MIL-STD-1840		The Primary defense standardization document for the selected CALS standards, identifies, by application, which industry standard and corresponding DoD standardization documentation to use It also provides standard “enveloping” procedures for transferring standard data forms
MIL-D-28000	IGES	Initial Graphics Exchange Specifications (IGES)- A neutral file format for the representation and transfer of product definition data among CAD/CAM systems and application programs
MIL-M-28001	SGML	Standard Generalization Markup Language (SGML)- Markup requirements, tagging and generic style specifications for page-oriented documents text
MIL-R-28002	CCITT GROUP 4	The efficient compression of scanned raster images. Uses the code from the Group 4 facsimile recommendation of the International Telegraph and Telephone Consultative Committee (CCITT). A “filed” form is described by using the architecture nomenclature of International Standard, IS 18613.
MIL-D-28003	CGM	Computer Graphics Metafile (CGM)- A neutral format for the description, storage and communication of graphical

		information
EC/EDI	EC/EDI	Electronic Commerce/Electronic Data Interchange (EC/EDI)- The electronic interchange of business information between trading partners. Uses standards formats currently defined by ANSI X12 in the U.S., EDIFACT in the Europe, and AECMA 2000 for NATO
STEP	STEP	Standard for the Exchange of Product Model Data (STEP)- A computer interpretable data representation format being developed to include all product model data necessary to define geometry, function and behavior of a product throughout its life cycle. Product Data Exchange using STEP (PDES) is the U.S. standards activity supporting STEP
MIL-STD-974	CITIS	Contractor Integrated Technical Information Service (CITIS)- Contractor provided-service for electronic access and/or delivery of contractually committed business and technical information on a need to know basis.
MIL-M-87268	IETM	Prescribes the requirements governing the creation of Interactive Electronic Technical Manual (IETM) presentation software applicable to a computer -controlled Electronic Display System (EDS).
MIL-D-87269	IETM	Prescribes the interchange format for delivery of an IETM database to the Government
MIL-Q-87270	IETM	Prescribes the requirements for an IETM Contractor's Quality Assurance (QA) program

MIL-HDBK-SGML (draft)	SGML	Provides guidance in the application of MIL-M-28001, which is based on ISO 8879, Standard Generalized Markup Language. Data prepared in accordance with these guidelines will facilitate the automated storage, retrieval, interchange, and processing of technical documents from varied data sources
-----------------------	------	--

(Villeca, 1997:9)

Appendix C. Classes of IETMs

CLASS	DISPLAY	DATA FORMAT	FUNCTIONALITY
0	Full page viewing Printed pages Microfilm images	Film Word processor SGML or Page description language	Printed pages View pages (No intelligent indexing)
1	Full page viewing Page-turner/Next function Intelligent index for user access to page images Page integrity preserved	Bitmap (raster) Indexing and header files (Navy Mil 29532) MIL-R-28001 or Postscript pages Generic COTS imaging system formats	Access pages by intelligent index/header info View page with pan, zoom, etc., tools Limited use of hot-spots Useful for library or reference use
2	Primary view is scrolling text window Hot-spot access (Hyper-links) to other text or graphics User selection and navigation aids (key-word search, on-line indices Minimal text-formatting for display User selectable call to (launch) another process	Text - ASCII Graphics -whatever viewer support -e.g., BMP or CALS Can be SGML tagged - no page breaks (browser) Access/index often COTS dependent with Hypertext browser Generic: COTS with Hypertext browser	Browse through scrolling info User selection of graphics or hot-spot reference to more text Hot-spot and cross-reference usually added after original authoring
3	View smaller logical block	Linear ASCII with SGML	Dialog-driven interaction

	<p>of text - less use of scrolling</p> <p>Interaction through dialog boxes</p> <p>Interaction per MIL-M-87268 to extent possible</p> <p>Text and graphic simultaneously displayed in separate window when keyed together</p>	<p>tags SGML with content vice format tags</p> <p>Maximum use of MIL-D-87269</p> <p>Generic: SGML tags equivalent to MIL-D-87269</p>	<p>Logical display of data in accordance with content</p> <p>Logical NEXT and BACK functions</p> <p>User-selectable cross-refs and indices</p> <p>Content specific help available</p>
4	<p>View smaller logical block of text - very limited use of scrolling</p> <p>Interaction through dialog boxes with user prompts</p> <p>Interaction per MIL-M-87268</p> <p>Text and graphic simultaneously displayed in separate window when keyed together</p>	<p>Fully attributed DB elements (MIL-D-87269)</p> <p>MIL-D-87269 content tags with full conformance with Generic Level Object Outlines (architectural forms)</p> <p>Authored directly to database for interactive electronic output</p> <p>Data managed by a DBMS</p> <p>Interactive features "authored in" vice added-on</p> <p>Generic: COTS equal to MIL-D-87269 data definition and tags</p>	<p>Dialog-driven interaction</p> <p>Logical display of data in accordance with content</p> <p>Logical NEXT and BACK functions</p> <p>Useful as interactive maintenance aid</p> <p>User-selectable cross-refs and indices</p> <p>Content specific help available</p>
5	<p>Same as Class 4 for IETM function</p> <p>Interactive electronic display per MIL-M-87268</p> <p>Expert system allows same display session and view</p>	<p>IETM info integrated at the data level with other application info</p> <p>Does not use separate databases for other application data.</p>	<p>Single viewing system for simultaneous access to multiple info sources</p> <p>Same as Class 4 for IETM functions</p> <p>Expert system to assist in</p>

	<p>system to provide simultaneous access to many differing functions (e.g., supply, training, troubleshooting)</p>	<p>Identical to Class 4 standards for IETM applications data per MIL-D-87269</p> <p>Coding for Expert Systems and AI modules when used</p> <p>Generic: COTS equal to MIL-D-87269 data definition and tags</p>	<p>NEXT functions, based on info gathered in session</p>
--	--	---	--

(Jorgensen, 1994:8)

Appendix D. Summary of Research Questions Given to O'Neil & Associates

General Questions about IETM development process in O'Neil & Associates, Inc.

1. Description of O'Neil & Associates, Inc.
2. In which cases are IETMs preferred?
3. Steps of an IETM development process.
4. Identification of each step.
 - How long does it take to complete each step?
 - How many people work on it, inside/outside and why?
 - How does each worker contribute to the project, how much time do they spend?
 - What are the inputs and outputs for the step?
 - How is the decision made among alternatives (type of software, hardware, methods, etc.)? For example which one is preferred, scanning and using OCR or rewriting in a different way?
 - What are the components of each step?
5. Schedule and resource allocation for the projects.
6. What is the schedule plan, does each step have to follow each other, or can they be done simultaneously?
7. How much time and resource allocated for each step? What are the resources?
8. Cost issues of projects.

- Which cost allocation method is used? How correct do you think is this method?

Difficulties in allocating cost in that kind of a project.

- Total cost of projects, cost of each step, cost among alternatives.

9. Life cycle issues (maintenance and support).

Questions about Intercept Project

1. Description of the customer.
2. Description of the project.
3. Implementation of IETM development steps in that case.
4. Total cost, cost of each step, and cost allocation methods.
5. Problems encountered in the project, and how were they handled.
6. Interviews with the personnel who worked on the project.
7. Schedule and resource allocation for the project.
8. Changes from general implementation methods and their reasons.
9. Interactions between the customer and the firm.

References

- Adobe Web Page. "About PDF" WWW,
<http://www.adobe.com/prodindex/acrobat/adobepdf.html>, September 1998.
- Advanced Integrated Maintenance Web Page. "Interactive Electronic Technical Manuals Cost/Benefit Analysis" WWW, <http://www.htsc.com/AIMSS/COST.HTML>, May 1998.
- Ahearn, Hally. "SGML and The New Yorker Magazine," Technical Communication, 40:226-228, (Second Quarter 1993).
- Air Force Product Data Modernization Office. "Air Force Digital Data Strategy" WWW, <http://www.pdsdm.wpafb.af.mil/datamgt/junstrat.htm>, September 1998.
- Air Transport Association Web Page. "ATA Publications-SPEC 2100," WWW,
<http://www.air-transport.org/pub/a090.htm>, September 1998.
- Arbortext Web Page. "SGML: Getting Started," White paper, WWW,
<http://www.arbortext.com/wp.html>, September 1998.
- Balise Web Page. "Balise and Legacy Data Conversion," WWW,
<http://www.balise.berger-levrault.fr/press/papers/baluptra.htm>, September 1998.
- Bayne, Ted and Moira Meehan. "CALS Makes an Impression in Publishing," Computer World, 23: 73, (August 1989).
- Burnard, Lou. "TEI EDW25: What is SGML and How Does It Help," WWW,
<http://www.oasis-open.org/covr/edw25.html>, May 1998.
- Byrd, Terry A., Kathy L. Cossick, and Robert W. Zmud. "A Synthesis of Research on Requirements Analysis and Knowledge Acquisition Techniques," MIS Quarterly, 117-138, March 1992.
- Commerce at Light Speed (CALS). "STEP," WWW,
<http://www.cals.com/step/index.htm>, May 1998.
- Conrad, Kurt. "Tools for Implementing SGML-Based Information Systems: Viewers and Browsers, Text Retrieval Engines, and CD-ROMs," WWW,
<http://www.SagebrushGroup.com/delivery.htm>, August 1998.

Conway, Cheryl V. A Specific Need for Hypermedia. Report #SETR-90-001, Allied-Signal Aerospace Company Bendix Test Systems Division, Teterboro NJ (October 1990).

Cooper, Donald R. and C. William Emory. Business Research Methods. USA: The McGraw-Hill Companies, Inc., 1995.

Davidson, W. J. "SGML Authoring Tools for Technical Communication," Technical Communication, 40: 403-409, (Third Quarter 1993).

Delivery and Presentation Committee-Interactive Electronic Technical Manual Study Group. Functional Requirements Document Delivery and Presentation System for Interactive Electronic Technical Manuals. Product Data Systems Modernization Program Office, Dayton OH, 28 February 1991.

Department of Defense Web Page. Defense Acquisition 1996: DoD 5000.2-R, WWW, http://www.acq.osd.mil/te/programs/se/dod_5000-2r.html, May 1998.

Dewire, Dawna T. Text Management. New York: McGraw-Hill, Inc., 1994

Electronic Commerce Connection, Inc. "Configuration Control for Product Documentation: A Way of Integrating STEP & SGML," WWW, http://www.eccnet.com/step/White_paper/page2.html#problem_domain, May 1998.

Electro-Tech International Corporation (a). Contractual Language Guidance Document: Guidance for Acquisition of U.S. Army Equipment Publications Digital Files. Contract No: DAAB07-89-D-A047, Task No: 89-003 (21 December 1990).

Electro-Tech International Corporation (b). Lessons Learned from a Case Study of the Acquisition of Digital Files for U.S. Army Equipment Publications. Contract No:DAAB07-89-D-A047, Task No:89-003, (21 December 1990).

Evans, Debbie. Project Manager, O'Neil & Associates, Inc., Dayton OH. Personal Interview. 25 Jun 1998.

European Association of Aerospace Industries Web Page. "AECMA Simplified English," WWW, <http://www.aecma.org/senglish.htm>, September 1998

Flynn, Peter and others. "Frequently Asked Questions About the Extensible Markup Language: What is XML for," XML Special Interest Group, WWW, <http://www.ucc.ie/xml/#FAQ-ACRO>, May 1998.

Fuller, J. Joseph. "Tri-Service Interactive Electronic Technical Manual (IETM) Technology Working Group," CALS Expo USA 1997, 15 October 1997.

Gross, Mark. "A Case Study of Conversion," <Tag> SGML Newsletter, WWW, <http://tag.sgml.com/08120102.htm>, December 1995.

Grosso, Paul. "Concepts Behind SGML-aware Authoring," Organization for the Advancement of Structured Information Standards, WWW, <http://www.sgmlopen.org/html/sgml-aware-authoring.html>, September 1998.

Harvey, Betty. "How STEP/SGML and XML/EDI Initiatives Will Impact Future Development of IETMs," SGML\XMLEurope, (May 1998). WWW, <http://www.eccnet.com/papers/ietm.html>, May 1998.

Holloway, Steven C. The Air Force Representative in Tri-Service IETM Working Group, Product Data Systems Modernization Program Office, Dayton, OH. Personal Interview. July 1998.

IETM Technology Working Group. "Charter of The Tri-Service IETM Technology Working Group," WWW, http://www.acq.osd.mil/cals/ietm_info/ietmchrt.html, September 1998.

Information Architects Web Page. "Conversion in the SGML Industry," White Paper, WWW, <http://iai.sgml.com/sgmlconversion.htm> May 1998.

ISO/IEC JTC1/WG4 N1946 Web Page. "Document Description Languages," WWW, <http://www.ornl.gov/sgml/wg8/document/1194.htm>, September 1998.

Jorgensen, Eric L. "Proposed Web-based Architecture for the Interoperability of Naval Aviation IETMs," CDNSWC-TSSD-98-005 Total Ship Systems Directorate Research and Development Report, WWW, <ftp://navycals.dt.navy.mil/pub/ietm>, March 1998.

Jorgensen, Eric L. DoD Classes of Electronic Technical Manuals. Carderock Division Naval Surface Warfare Center CDNSWC/TM-18-94/11, April 1994.

Jul, Erik. "SGML Plays Important Role in Electronic Publishing" OCLC Newsletter, 13-15 (November 1992).

Knox, Rita E. "Do We Need a Theory of Standards? Lessons Learned from CALS and STEP," CALS EXPO International 1993, AP-4-AP-50, November 1993.

Kribs, H. D. and L. J. Mark. "A Survey of Interactive Electronic Technical Manuals Used for Training and Education," Annual Conference, pg. TR-Thur (11:15)-1. Arlington VA, 1995.

Kusinski, Denise. "Flying High Status of ATA-100," <Tag> SGML Newsletter, WWW, <http://tag.sgml.com/4031101.htm>, March 1991.

Leenders, Michiel R. and James Erskine. A Case Research: The Case Writing Process. Ontario, The University of Western Ontario, 1989.

Magliery, Tom. "SGML- Capable Web Browsing," WWW, <http://sdg.ncsa.uiuc.edu/~mag/work/SGML2HTML/sgmlbrowsers.html>, September 1998.

Martin, Jim. "The Challenge of Interactive Technical Communication," The Journal of the Society for Technical Communication, 42, Issue95: (1995).

Masincup, W. E., Bryan, J. S., and Ochs L.M. "Development of an Interactive Electronic Manual," Journal of Engineering for Gas Turbines&Power, Vol. 118, Issue 3: 632-635 (July 1996).

McNamara, Michael J. "The Document Database: Relational, Object Oriented or Hybrid?" WWW, <http://www.oasis-open.org/cover/mcnam1> September 1998.

Milligan, Thomas R. Vice President, O'Neil & Associates, Inc., Dayton, OH. Personal Interview. February 1998.

Munguia, Arthur A. Associate Professor, Department of Systems Acquisition Management, Air Force Institute of Technology, Wright-Patterson AFB OH. Personal Interview. December 1998.

Munguia, Arthur A. Associate Professor, Department of Systems Acquisition Management, Air Force Institute of Technology, Wright-Patterson AFB OH. Personal Interview. November 1997.

Munguia, Arthur A. Class handout, Introduction to Digital Data, School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB OH, March 1997.

Navy CALS Web Page. "Interactive Electronic Technical Manuals," WWW, <http://navysgml.dt.navy.mil/ietm.html/classes.html>, September 1998.

NAWCAD Information Technology Branch Web Page (a). "Aegis Radio Communications System IETM," WWW, <http://www.nawcsti.navy.mil/rcs.htm>, May 1998.

NAWCAD Information Technology Branch Web Page (b). "Interactive Electronic Technical Manuals," WWW, <http://www.nawcsti.navy.mil/mid/ietms/html>, May 1998.

O'Neil & Associates (a). About CALS and SGML. Dayton: Marketing Department, O'Neil & Associates, Inc., November 1995.

O'Neil & Associates (b). IGES, CCITT-G4, or CGM. Dayton: Marketing Department, O'Neil & Associates, Inc., November 1993.

O'Neil & Associates (c). Electronic Publishing. Dayton: Marketing Department, O'Neil & Associates, Inc., 1997.

O'Neil & Associates (d). Conversion of GEAE ATA Shop Manuals to SGML. Production Process Plan. Dayton: Marketing Department, O'Neil & Associates, Inc., July 1997.

O'Neil & Associates (e). O'Neil Participates in International SGML Based Aircraft Program. Dayton: Marketing Department, O'Neil & Associates, Inc., October 1996.

Pechersky, Paul N. "Easing Paper Flow Could Help Slash DOD Budget," Computer World, 23, Issue 33: 67-72 (August 1989).

Pepper, Steve. "SGML TOOLS," SGML Europe Conference 94, WWW, <http://www.infotek.no/sgmltool/94paper.htm> (September 1998).

Prettyman, Maureen. "Conversion to SGML," <Tag> SGML Newsletter, WWW, <http://tag.sgml.com/09090601.htm>, September 1996.

SAE J2008 Web Page. "Status of SAE J2008," WWW, <http://www.mcs.net/~dken/sae.htm#over>, September 1998.

- Sengupta, Arijit. "Design and Implementation of a Database Environment for the Manipulation of Structured Documents", WWW,
<http://www.cs.indiana.edu/hyplan/asengupt/thesis/oral/oral.html>, September 1998.
- Severson, Eric. "The Art of SGML Conversion: Eating Your Vegetables and Enjoying Dessert," Organization for the Advancement of Structured Information Standards, WWW, <http://209.224.8.177/html/art-of-sgml-conversion.html>, September 1998.
- Sperberg, C.M., McQueen Burnard, and Lou Burnard. "A Gentle Introduction to SGML: Chapter two of Guidelines for Electronic Text Encoding and Interchange (TEI P3)," WWW, <http://sable.ox.ac.uk/ota/teip3sg/index.html>, September 1998.
- Sudman, Seymour and Norman M. Bradburn. Asking Questions. California: Jossey-Bass, Inc., 1982.
- Tisdale, Steven R. "Your Next Generation TM... The Interactive Electronic Technical Manual (IETM)," WWW, <http://www.usaals.com>, September 1998.
- Ventura, Cheryl A. Why Use Electronic Manuals? Report #SETR-87-001, Allied-Signal Aerospace Company Bendix Test Systems Division, Teterboro NJ (February 1987).
- Villeca, Ralph C. A Comparative Analysis Traditional Book Form Technical Manuals Versus Interactive Electronic Technical Manuals. MA thesis, Farleigh Dickinson University, Madison NJ (May 1997).
- Waldt, Dale. "Power of SGML Databases," <Tag> SGML Newsletter, WWW, <http://tag.sgml.com/06080501.htm>, August 1993.
- Wood, Chris. "Tornado F3 Conversion of Publications Data to AECMA 1000D- A Case Study," Graphics Communications Association SGML Europe 97, 27-30 (1997).
- World Wide Web Consortium Web Page. "Introduction to HTML 4.0," WWW, <http://www.w3.org/TR/REC-html40/intro/intro.html#h-2.2.1>, September 1998.
- Yin, Robert K. Case Study Research. California: Sage Publication, Inc., 1994.

Vita

Lt. Ali N. Karabulut was born on 26 March 1972 in Corlu, Turkey. He graduated from Ankara Ataturk Anadolu Lisesi in 1990 and entered Turkish Air Force Academy in Istanbul, Turkey. He graduated with a Bachelor of Science degree in Industrial Engineering and as a 2nd Lieutenant in the Turkish Air Force.

His first assignment was in Gaziemir Hava Teknik Okullar Komutanligi, Izmir. He completed the Security and Intelligence course and graduated in 1996. His second assignment was at Incirlik Tesis Komutanligi as a Security and Intelligence officer. In June 1997, he entered the School of Logistics and Acquisition Management, Air Force Institute of Technology.

Permanent Address: OYAK Sitesi 36. Giris
No.24 Cankaya, Ankara
Turkey

Vita

Lieutenant Hilmi Oz was born on 17 September 1972 in Izmir, Turkiye. He graduated from Maltepe Military High School in 1991 and entered the Turkish Air Force Academy in Istanbul, Turkiye. He graduated with a Bachelor of Science degree in Electronics Engineering in August 1995. He received his commission on 30 August 1995 upon graduation from the Turkish Air Force Academy.

His first assignment was at Cigli AFB as a supply officer. In April 1993, he entered the Schools of Logistics and Acquisition Management, Air Force Institute of Technology.

Permanent Address: 9754 Sokak No: 47
Limonetepe, Izmir
Turkiye

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 074-0188
<p>Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503</p>			
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED	
	December 1998	Master's Thesis	
4. TITLE AND SUBTITLE HOW TO DEVELOP AN INTERACTIVE ELECTRONIC TECHNICAL MANUAL: AN INDUSTRY PERSPECTIVE		5. FUNDING NUMBERS	
6. AUTHOR(S) Ali N. Karabulut, 1 st Lieutenant, Turkish Air Force Hilmi Oz, 1 st Lieutenant, Turkish Air Force			
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S) Air Force Institute of Technology 2750 P Street WPAFB, OH 45433-7765		8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/GLM/LAL/98S-9	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N / A		10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.		12b. DISTRIBUTION CODE	
13. ABSTRACT (<i>Maximum 200 Words</i>) Improvements in technology, especially in computer science, in the last two decades have made it possible, and preferable to develop digital technical manuals. A digital manual, which is called an Interactive Electronic Technical Manual (IETM), is a package of information required for the diagnosis and maintenance of a weapon systems, optimally arranged and formatted for interactive screen presentation to the end-user. Being the largest organization in the U.S., the Department of Defense has pioneered in the development of IETM concept as well as in the establishment of its standards. There have been many researches done about different IETM applications and their effectiveness in DoD environment. However, little research has been done in the area of how an IETM is developed in a civilian environment. This thesis identifies what it takes to develop an IETM in a civilian environment and investigates differentiating factors of commercial industry. In addition to the identification of IETM development steps in a case study, IETM standards, IETM development specifications in industry as well as in military, problems areas in today's IETM development environment, and DoD classification of IETMs are also discussed.			
14. SUBJECT TERMS ABDR, ABDAR, BDR, Combat Maintenance, Repairs Content Analysis, Delphi Method, Friedman Test, Logistics Management, Maintenance Management, Program Management			15. NUMBER OF PAGES 129
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. Please return completed questionnaire to: AIR FORCE INSTITUTE OF TECHNOLOGY/LAC, 2950 P STREET, WRIGHT-PATTERSON AFB OH 45433-7765. Your response is important. Thank you.

1. Did this research contribute to a current research project? a. Yes b. No
2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it? a. Yes b. No
3. Please estimate what this research would have cost in terms of manpower and dollars if it had been accomplished under contract or if it had been done in-house.

Man Years _____ \$ _____

4. Whether or not you were able to establish an equivalent value for this research (in Question 3), what is your estimate of its significance?

a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments (Please feel free to use a separate sheet for more detailed answers and include it with this form):

Name and Grade

Organization

Position or Title

Address